U. S. DEPARTMENT OF AGRICULTURE.

OFFICE OF EXPERIMENT STATIONS—BULLETIN NO. 113.

A. C. TRUE, Director.

IRRIGATION OF RICE IN THE UNITED STATES.

BY

FRANK BOND AND GEORGE H. KEENEY.

Agents and Experts, Irrigation Investigations.

Under the direction of

ELWOOD MEAD.

Expert in Charge of Irrigation Investigations.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1902.

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OFFICE OF EXPERIMENT STATIONS.

A. C. True, Ph. D., *Director*.
E. W. Allen, Ph. D., *Assistant Director*.

IRRIGATION INVESTIGATIONS.

Elwood Mead, *Irrigation Expert in Charge*.
C. T. Johnston, *Expert Assistant*.
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Frank Adams, *Agent and Expert*.
Frank Bond, *Agent and Expert*.

LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Office of Experiment Stations,
Washington, D. C., April 14, 1902.

Sir: I have the honor to transmit herewith a report on irrigation of rice in the United States, prepared under the direction of Prof. Elwood Mead, expert in charge of irrigation investigations. This report embodies the results of investigations made in response to requests for information regarding means to be employed for overcoming difficulties which are now obstructing the progress of the rice industry in this country. It is believed that the information contained in the report constitutes a useful contribution to this subject and that the suggestions herein given will be of practical usefulness to our rice growers.

Very respectfully

A. C. True,
Director.

Hon. James Wilson,
Secretary of Agriculture.

LETTER OF SUBMITTAL.

U. S. Department of Agriculture,
Office of Experiment Stations,
Irrigation Investigations,
Washington, D. C., April 2, 1902.

Sir: I have the honor to submit herewith a report on the irrigation of rice in the United States, including a report on the irrigation of rice on the uplands of Louisiana and Texas, by Frank Bond, agent and expert in irrigation investigations, and a report on irrigation of rice in North Carolina, South Carolina, and Georgia, by George H. Keeney, special agent, irrigation investigations.

During the last half century rice production in the United States has grown but little, the crop of 1850, as given by the census of that year, being almost as large as the maximum crop reported since that time, and considerably larger than the average crop of the last ten years. While rice production has remained practically stationary, there has been a decline in the South Atlantic States and an increase in the western Gulf States. Within the past few years the raising of rice in Louisiana and Texas has developed into one of the leading industries of that region, and has given great value to lands heretofore used only for grazing, and to water which had been allowed to waste into the Gulf of Mexico. This development has been so rapid that laws and institutions have not kept pace with the industry, and already serious loss has resulted from the failure of those States to provide for the establishment and protection of titles to the use of water. Streams have been overappropriated, and early investors who should have been protected in their use of water have been made to suffer with the later comers, who should have been prevented from diverting water until earlier users were supplied. This study of conditions in Louisiana and Texas was undertaken for the purpose of applying to those States, so far as conditions were similar, the lessons learned in those parts of the country where irrigation has long been practiced. It is hoped that this report may aid the rice growers and the lawmakers of Louisiana and Texas in the adoption of codes of irrigation laws which will bring about the highest development of their resources.

The rice industry in the South Atlantic States has been on the decline for many years, owing chiefly to the decline in the price of rice and the inability of the rice growers in those States to cheapen production sufficiently to make rice growing profitable under the new conditions. If rice farming along the Atlantic coast could be so modified as to permit of the use of labor-saving machinery, there is little question that the industry in that region could be carried on at a profit. The descriptive portions of the accompanying report on the industry in Louisiana and Texas should suggest to the rice growers of the South Atlantic States methods which will enable them to compete with cheap labor abroad and with labor-saving machinery at home.

During the past ten years the United States have produced less than half the rice consumed in this country, the average importation for that time being 172,736,057 pounds per annum, having a value of $3,185,968. Rice as yet enters very little into everyday use in this country. With the present large importation and the increasing use of rice as a staple food rather than a luxury the possibilities for the expansion of this industry are unlimited.

There have been frequent calls upon this Office for information regarding pumping water for the irrigation of rice and other crops. The attempt has been made to meet this demand by collecting information regarding the cost of pumps and their installation and operation, and their duty in the irrigation of rice. This information is included in the report of Mr. Bond.

Respectfully submitted.

ELWOOD MEAD,
Expert in Charge of Irrigation Investigations.

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IRRIGATION OF RICE ON THE UPLANDS OF LOUISIANA AND TEXAS.

By Frank Bond,

Agent and Expert, Irrigation Investigations.

EARLY RICE GROWING.

The first growers of rice in the district now devoted to the production of this cereal in Louisiana and Texas (Pl. I) were the Acadians, French settlers of Nova Scotia, who were driven from their homes at the time England took over that land from France. Longfellow, in poem, and George W. Cable, in touching prose story, have made the world acquainted with this simple pastoral people, who, for nearly one hundred and fifty years following their exile in 1755, lived uneventful and happy lives in their new Southern home.

Their chief source of income was the herds of cattle which roamed at will over the upland prairies of this region, but simple agriculture with primitive machinery was carried on, and rice was a common product of the farm. Both the climate and the soil of Louisiana are adapted to the kind of agriculture which requires little effort on the part of the husbandman. The people had few wants which the new country did not supply abundantly. A few acres planted in rice, corn, and sweet potatoes, with the herds brought from Nova Scotia, and the wild fowl and fish, both of which were exceedingly abundant, satisfied their desires. Wheat, however, could not be raised and bread was made from corn meal alone. The rice crop was small, but during favorable seasons the harvest was sufficient to tide over those years when there was a deficiency in rainfall or excessive precipitation, both of which were injurious, reducing or ruining the crop. The Acadian farmer depended wholly upon rainfall for the water necessary to flood his rice crop, as well as for his other agricultural products.

Viewed from the standpoint of the value of the returns, early rice growing in Louisiana offered no attractions for that capital which, in recent years, has developed vast bodies of land not formerly cultivated by the Acadians, but adjacent to their little fields, and which were believed by them to be entirely worthless except for grazing purposes. But little improvement in method was possible so long as a farmer

limited the acreage planted to the area he could cultivate and harvest by hand, or so long as he was dependent upon rainfall for the floods which moistened his rice fields. This was particularly true so long as he was confined to the low alluvial lands along the sluggish bayous. His methods of cultivation were too primitive to permit of progress. However, Acadian success with "Providence rice," as it is now called, convinced other and more ambitious settlers who went to Louisiana after the civil war that the business of rice growing could be made profitable. The necessity of sufficient water at the critical period in the growth of the crop was made plain and they attempted to supply the deficiency. The heavy rainfalls were not allowed to drain off into the bayous, but were dammed back in the fields by levees raised with the shovel, and the water needed was thus held for a time for the growing rice. When the water was needed, these levees were cut and the water was allowed to flow over the fields below. But when there was no rain, the rice suffered and the crop often failed to pay the cost of harvesting and marketing. The shovel supplement to the natural precipitation increased the probability of a crop, but the acreage planted did not greatly increase because of the labor needed to construct the pioneer levees, and because of the evident uncertainty of the water supply. Land available for this character of work was limited; also, it being necessary to select the very lowest lands of the small farms for the rice fields, the higher lands being used as a watershed to collect rainfall. Drainage of the lower lands was not as perfect as desired and all harvesting continued to be done with the sickle. Thrashing was done with the flail, and winnowing the grain from the chaff was delegated to the breezes, which blew away the chaff as the grain was poured from one vessel to another. Under such conditions the area of the rice farm was reduced below that which was needed to make rice growing for commercial purposes profitable. Investigation of the soil of the prairie lands elevated from 10 to 70 feet above the bayous, and experiments in rice growing thereon, during exceptionally wet seasons, forced the conclusion that these lands were as well adapted for rice culture as the lower bottom lands, if the necessary water could be supplied. There appeared to be an abundance of fresh water in the bayous and the problem pressing for solution was how to get this water upon the higher lands.

THE STEAM PUMP UTILIZED.

Small steam pumps were at first used to raise the water from the coulees, which were dammed and allowed to fill during the winter months. In the light of subsequent success this method was but a makeshift, but at the time it gave evidence of a future for artificial irrigation that promised much. Further and more extensive experiments followed until, in 1894, the forerunner of the pumping plants


SOUTH-EASTERN TEXAS.
SOUTH-WESTERN LOUISIANA.
MAP OF THE
LOUISIANA-TEXAS RICE DISTRICT
SHOWING THE EXTENSION OF
THE RICE CANAL
OVER THE ELEVATED PRAIRIE LANDS
OF BOTH STATES
ALL CANALS AND ARTESIAN WELLS CORRECTLY LOCATED
OFFICE OF EXPERIMENT STATIONS
IRRIGATION INVESTIGATIONS
EXPLANATION
Rice canals
Rice wells
Railroads
County and Parish Boundaries
State Boundaries
Timber land
Prairie
Marsh
GULF OF MEXICO
WALKER
SAN JACINTO
POLK
TYLER
BRAZOS
GRIMES
MONTGOMERY
WASHINGTON
HARDIN
JASPER
NEWTON
ORANGE
LIBERTY
AUSTIN
WALLER
HARRIS
JEFFERSON
CHAMBERS
COLORADO
FORT BEND
GALVESTON
WHARTON
BRAZORIA
MATAGORDA
GALVESTON BAY
SABINE LAKE
CALCASIEU
ST. LANDRY
ACADIA
LAFAYETTE
CAMERON
VERMILION
IBERIA
ST. MARTIN
VERMILION BAY
Marsh Island
HOUSTON
BEAUMONT
Longitude West from Greenwich

now used was established. This plant was erected upon the banks of the Bayou Plaquemine, parish of Acadia, La., 2 miles northwest of the town of Crowley. The pump employed was of a pattern used in the mining camps of the Northwest. It was a vacuum pump operated by condensing steam, which was admitted to cylinders direct from the boiler. The steam was condensed by injecting a spray of cold water into the cylinders. The pump was operated for several weeks at the beginning of the pumping season, when the water in the bayou was comparatively cool, but owing to the increasing temperature of the water, due to the summer heat and the reduction of the depth, the vacuum pump stopped work at the most critical period of the flooding season. This experiment, which was discouraging because of the money actually lost and because of the partial failure of the rice crop resulting, proved conclusively that the problem of raising rice by irrigation was in no degree speculative or problematical. Successful rice culture involved the establishment of pumping plants large enough to lift the water needed and the construction of canals to carry the water to the points of use.

The following year a centrifugal pump was substituted for the vacuum pump, and failure to do the work assigned to it was properly laid to its diminutive size. It was succeeded by a new and much larger pump, which was guaranteed to raise 5,000 gallons per minute. This pump was a pronounced success. Its operation during the summer of 1896 marked a new era in rice cultivation. This pump, while accomplishing the object for which it was purchased, represents in a limited degree only the heavy pumping machinery now used in the prairie land rice regions of southern Louisiana and Texas. Two styles of pumps are now in general use, the centrifugal and the rotary pumps, having discharge pipes which range in diameter from 12 to 60 inches, and which elevate from the bayou to the flume above from 20 to 100 or more cubic feet of water per second. In the larger plants compound Corliss engines of 400 to 800 horsepower used to run batteries of these pumps are not uncommon.

EFFECT OF IRRIGATION ON LAND VALUES.

The effect of successful irrigation on prairie lands far from the bayou and many feet above it was a marked rise in the value of such lands almost contemporaneous with the first crop of rice harvested therefrom. In 1888 these lands could be obtained at prices varying between $1 per acre and $3.50 per acre, the higher price being asked for the lower tracts which could be easily cultivated in corn, sugar cane, cotton, rice, and other characteristic crops of the region, while the upland prairie lands at some distance from the bayou could be had at $1 per acre. During the succeeding four or five years, when experiments were being made with various styles of pumps, the price of rice lands

rose to a maximum of $10, the average for all land being about $7 per acre. The increase was due chiefly to the fact that these years brought an excess of rainfall, and the farmer who had harvested two or three crops of Providence rice in sufficient quantity to make his business very profitable imagined the temporary condition was permanent, and that rice growing upon prairie land was already an established industry. But a dry season closed the series of experiments disastrously, many of those who had invested their all in upland rice being compelled to assign for the benefit of creditors.

In 1895, however, when the first large canals were completed and operated successfully, the average price of rice lands rose rapidly from $7 per acre to $10, $15, and $20 per acre. Rice lands under the large canals around Crowley, La., are now held at an average price of $30, a few choice locations bringing $50 per acre in 1901. Rice land not under canals and at a distance from the railroad may be had for $15 per acre in southwestern Louisiana, especially in the districts not yet invaded by the rice growers having unlimited capital to invest in canals and pumping plants.

THE RICE CANAL.

In the elevated districts and plains regions of the West water rises by living springs in the higher levels, and the streams therefrom have a heavy fall which permits of easy diversion near the place of use. In

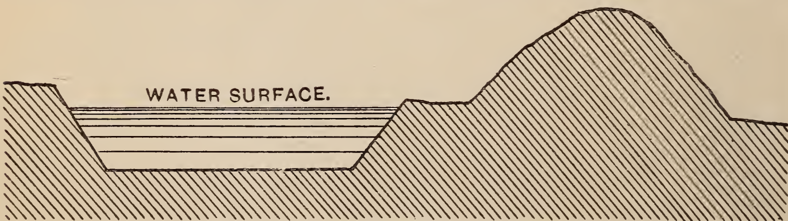


Fig. 1.—Cross section of Northwestern canal.

the irrigated rice district, however, no such encouragement is offered the farmer. The fresh water available for irrigation is all below the land over which it must be spread. It is contained in muddy, deep and extremely sluggish streams or bayous, whose current is often undiscoverable and whose water is held back by the salt tide waters of the Gulf of Mexico. The sea level in the rice districts is more often above the beds of these bayous than below them and this, added to the obstructions of dead and living forest and swamp growths, accounts for the lack of current in the streams.

The only point of similarity between the rice canal of the South and its predecessor of the Northwest is that both are filled with water for irrigation. The canal of the Northwest is dug below the surface of the land through which it passes (fig. 1); the rice canal is built on top

of the ground and the highest ground that can be found. The Northwestern canal holds water poorly on account of the porosity of the banks, due to the presence of gravel and sand in the soils of the regions traversed; the rice canal exhibits for banks levees which, when properly constructed, are practically impervious to water. The Northwestern canal, owing to its necessary gradient, will empty itself at one end only, while the rice canal, having a level foundation, would empty freely and, all things being equal, discharge the same volume of water at each end. Owing to the fall of the Northwestern canal, its water if dammed at the lower end would soon burst the banks, wash away all impediments, and flow into the nearest depression or stream below, while the rice canal, for the great distance between the first and last lifts at least, would if undisturbed by the erosive action of winds and rain remain filled indefinitely, evaporation and precipitation being the only elements left to change the level of its water surface.

LEVEE CONSTRUCTION.

The proper construction of the levees upon which the permanency of the rice canal depends is of first importance. The surface of the

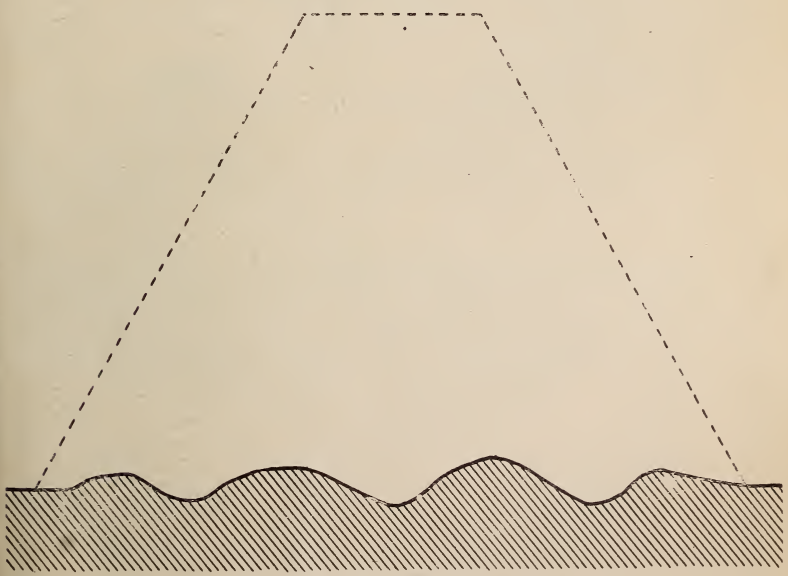


FIG. 2.—Foundation for a canal levee.

ground upon which the levees are to be erected should first be carefully cleared of all vegetation. The presence of decaying vegetation makes levees, otherwise good, porous instead of compact and impervious, and allows the passage of the little trickling streams which often result in serious breaks. The surface is next plowed 3 or 4 inches

deep to cut below the grass roots, and the soil thus turned over is thoroughly pulverized by a disk pulverizer or similar machine for the purpose of securing as perfect a blending of the soils and clays as possible. Finally a heavy breaking plow is used in making deep single furrows 3 to 5 feet apart, depending upon the width of the levee (fig. 2). Upon this foundation a permanent levee may be erected by the use of ordinary road scrapers or slips. Putting dry and light soils into levees invites seepage that is dangerous and the intelligent canal builder as far as possible now constructs levees of wet earth; or, if the work must be done during a dry period, exercises great care in filling the canal by admitting but a limited amount of water at first and letting it stand for forty-eight hours or more, thus giving the levees opportunity to become saturated gradually and firmly settled. Neglect of this precaution has caused many levee washouts.

In Liberty County, Tex., some trouble was had with high levees which were constructed with the so-called joint clays. These clays exhibited a tendency to cleavage, and allowed the water to penetrate the levee. The result was a gradual sliding of the levee upon its foundation, while levees in which sand was mixed with these clays remained intact and were impervious to water. For levees not exceeding 5 feet in height a ratio of height to base of one to one and one-half is usually adopted, and one to two for higher levees.

OBSTRUCTIONS IN CANALS.

Owing to the fact that it is desirable to keep the water on as high a level as possible, the practice of taking the earth for levees from the outside of the canals has been pretty generally adopted, but the later

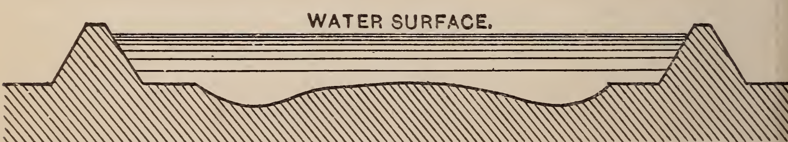
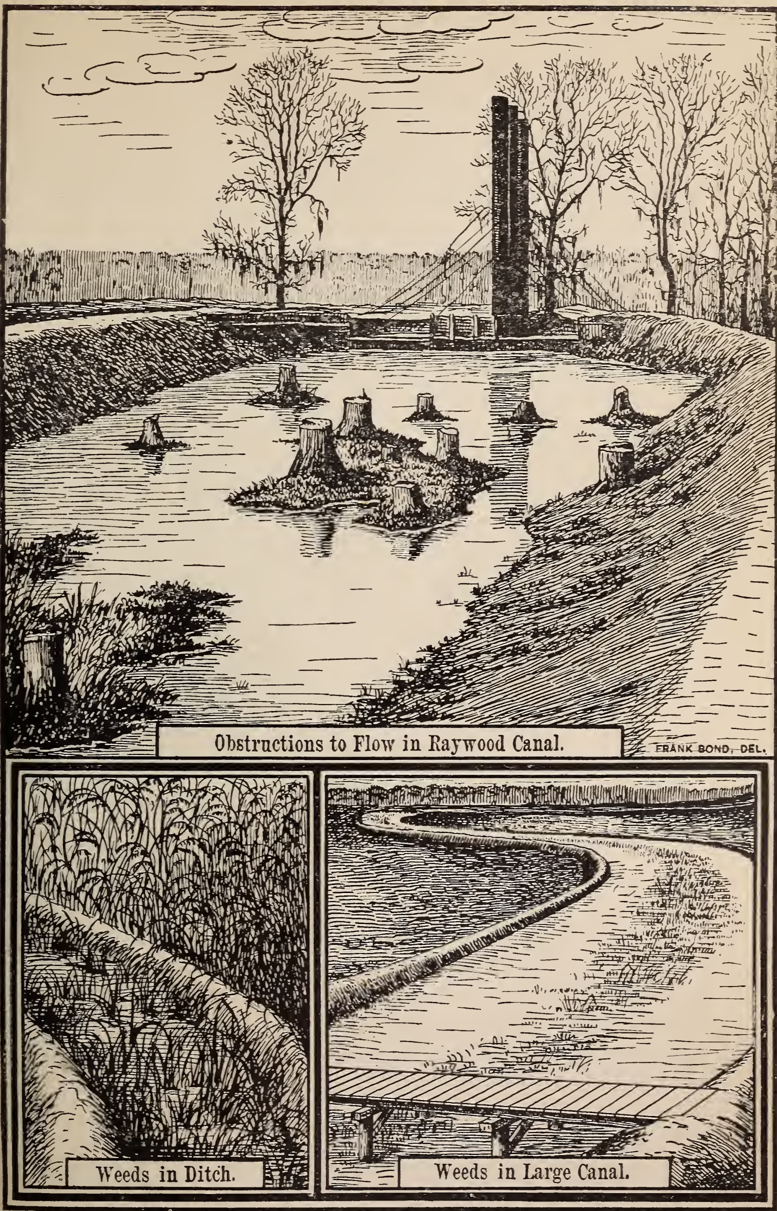


FIG. 3.—Cross section of a rice canal.

canal builders have in many instances taken the earth from the inside of the canal, not for the purpose of deepening it, but rather to clear away all vegetation, thereby securing upon both sides waterways entirely free from the obstructions which invariably retard the flow along the center line. A berm 4 or 5 feet wide is left between these shallow excavations and the foot of the levee for the protection of the latter (fig. 3). As all the water must be lifted, the small loss of elevation caused by shallow excavations within the canals is not a serious matter. Obstructions in the form of high weeds, rushes, and old stumps, necessitate wider canals or higher levees and, besides, insure



Obstructions to Flow in Raywood Canal.

Weeds in Ditch.

Weeds in Large Canal.

OBSTRUCTIONS IN RICE CANALS IN TEXAS.

greater or smaller regular crops of weeds whose seeds are carried directly to the rice fields. By the advocates of the method last described no earth for the levees is taken from the outside of the canals unless its removal is necessary to secure drainage of the fields adjacent. In spite of this precaution, however, after the first year, vegetation characteristic of ponds and boggy places in a warm and humid region springs up in the canals and, when not removed, seriously obstructs the flow of water. In the larger canals the shallower central portion sometimes exhibits this condition before the first season has closed. The rice farmer does not always seem to appreciate the reduction in capacity of his canal due to these obstructions, but nevertheless they should be removed from both the canals and ditches, especially if the capacity is at all strained in supplying water to the fields dependent upon them. In the smaller ditches and laterals the withdrawal of the water for several days at a time during the flooding season permits this troublesome vegetation to grow luxuriantly, seriously retarding the flow of water. Plowing seems to be the only remedy. Everything growing from the bottom of the ditch should be turned over, and during wet seasons when the ditches are filled only three or four times, the process should be repeated before each run of water. All growths of rank weeds and rushes in the main canals should be plowed under in the late spring just before the flooding season begins. Plate II, fig. 3, shows the appearance of a large canal whose levees were constructed from earth taken from the inside of the canal. The weeds have put in an appearance only along the center line, but if uninterrupted and maximum flow is desired they should be plowed under before pumping begins. The sketch of a weedy small ditch shows how serious the obstructions by luxuriant grasses may become in the midst of the irrigating season (Pl. II). Measurements of the current in canals grown up with rank weeds show that the capacity of such canals may be reduced 40 per cent by these obstructions.

The main canal of the Raywood Rice, Canal, and Milling Company, near Raywood, Tex., passes through 4 miles of timber composed of magnolia, cypress, live and other oaks, holly and gum trees, many of large size. Owing to the great hurry in constructing the canal, the trees which stood along the line of survey and between the levees were hastily cut, often 3 or 4 feet from the ground. During the pumping season the majority of these stumps are covered with water, but a few rise above the surface, giving a hint of their obstructive work below. The illustration (Pl. II) was taken just above the first relift, and shows the roof of the engine, boiler, and pump house at the end of the canal. The sketch was made in February, about three months before the pumping season began.

RICE FARMING.

Rice growing in southwestern Louisiana and southeastern Texas during the past five or six years has developed from an experiment into a stable industry of the greatest importance to the United States. Elevating the water from the bayous to the upland prairies will always be an expensive undertaking, and will require skill and experience in establishing and operating suitable machinery; but any farmer who has successfully raised wheat or oats is prepared to undertake the farming of rice. If the work of irrigation is excepted, the process is practically the same.

FIELD OR CUT LEVEES.

Field or cut levees divide the rice fields into tracts whose areas depend upon the slopes of the fields and the depth to which the irrigator desires to flood his crop. The old method of flooding the growing rice reduced the number of field cuts to the minimum. It was

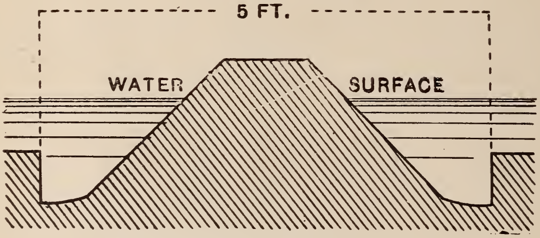


Fig. 4.—Cross-section of faulty field levee.

believed that rice should be flooded to a depth varying from 6 to 12 inches, and to accomplish this it was necessary to construct field levees between 12 and 18 inches high—as often the latter as the former. Levees of this height were turned up with a plow, the ratio of height to width being one to two or two and one-half, with a crown a foot or

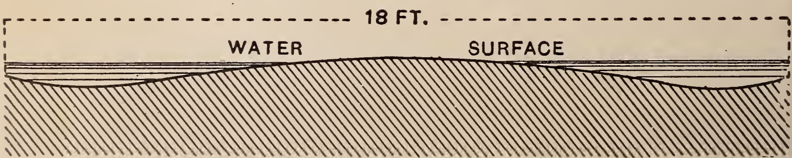


Fig. 5.—Cross-section of correct form of field levee.

more in width. These levees should stand above the water surface one-third of their total height (fig. 4).

These high levees are being superseded by lower and broader levees (fig. 5), the change being due to experiments and accidents which have induced the rice grower to modify his methods. These levees vary in width from 15 to 20 feet. They are constructed at such distances as

FIG. 1.—PLOWING RICE FIELDS WITH CATTLE, BAYOU PLAQUEMINE, LOUISIANA.

FIG. 2.—BINDERS AT WORK, RAYWOOD, TEX.

may be necessary to inclose cuts which are to be flooded not to exceed 3 or 4 inches on the lower side, and of such a height as will just prevent the overflow of water into the next cut below. Among the advantages offered by the low and wide field levees are the following:

(1) All kinds of farm machinery used in rice culture pass over the lower and broader levees freely and without damage to the levee.

(2) Lower levees withdraw no land from cultivation as they receive exactly the same treatment as the areas they inclose, and since the water rises practically to their summits, almost an average crop of rice is raised thereon.

(3) It is universally conceded that the faulty field levee is seriously responsible for the production of noxious grasses and plants, including the voluntary red rice, the greatest bane of the rice grower. The harvesting of a crop from the slopes and summit of the levee will remove this pest, thereby insuring the highest market price for the crop.

The correct form of levee is equally well adapted to all rice fields, no matter what the fall of the land may be. If the fall is greater than the average, more levees will be required, the cuts being made smaller. If less than the average, fewer levees may be made.

The change from the old form to the correct form has as yet only begun. The causes of the diffidence shown lie chiefly in the fact that more time is necessary for the construction of the correct levee and for the releveling of the fields in such a way as will provide for a greater number of cuts than have been in use.

METHODS OF FARMING.

The land is plowed with gang plows in the fall or spring, sometimes both, then disked and harrowed thoroughly (Pl. III, fig. 1). Planting is done with the broadcast machine attached to an ordinary farm wagon, or the seed is drilled in rows from 7 to 8 inches apart, the latter method insuring a better crop. During the planting season, which extends from April 1 to June 15, or later, no water is put upon the land, dependence being placed upon rainfall to sprout the seed and promote the growth of the plant for a period varying between one and two months, depending upon the season and water supply. Flooding usually begins when the rice reaches a height varying between 6 and 10 inches, and from this time on until the grain is in the milk and well formed, a period of about seventy days, the fields are kept flooded.

About ten days before harvest the levees are cut and the fields are drained. The grain rapidly hardens and matures, and by the time it is ready to cut the field is sufficiently dry to permit the use of the reaper and binder. This machine is identical with that used in the grain fields elsewhere in the United States (Pl. III, fig. 2). The sheaves of rice are shocked in the field immediately after the binder, ten sheaves to a shock being the rule, in order that there may be a free

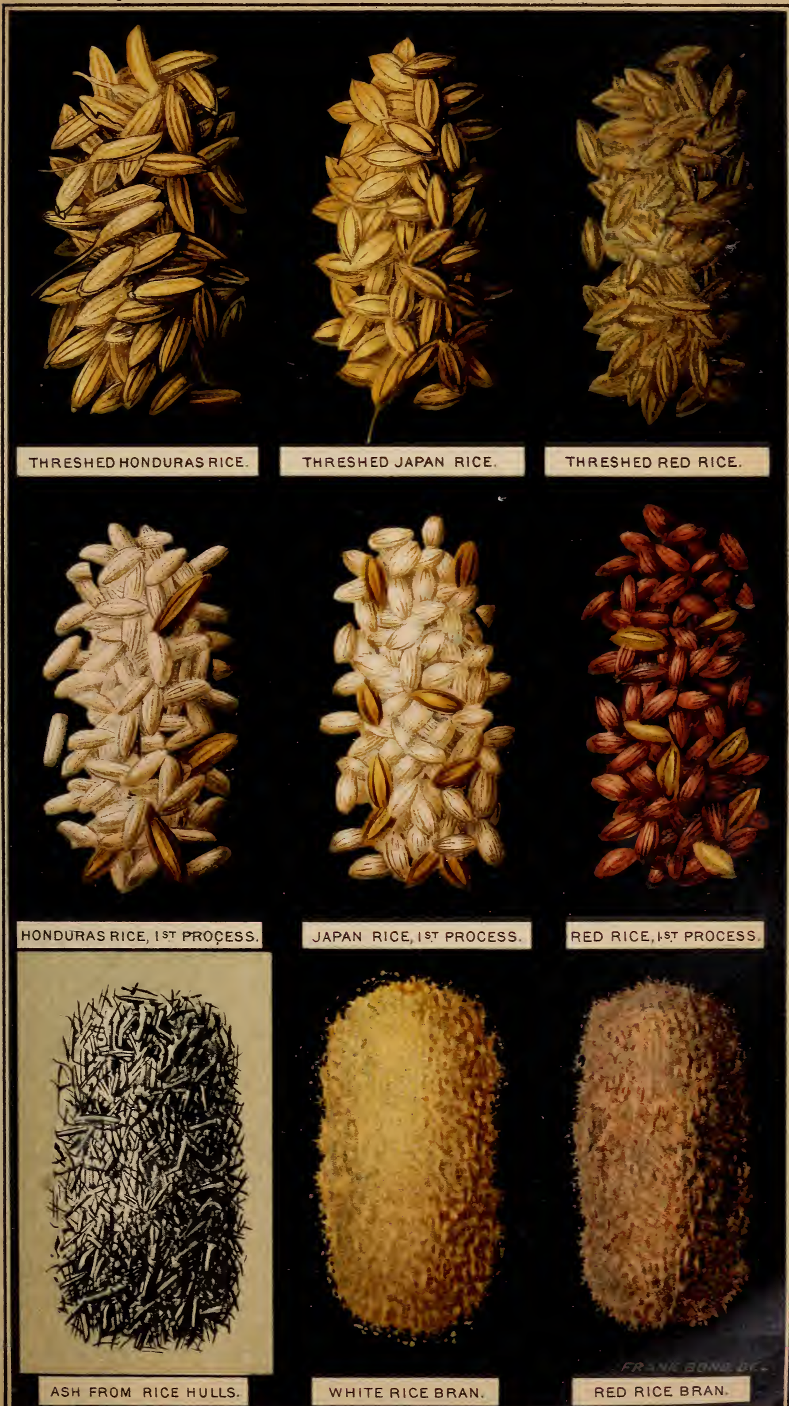
circulation of air to dry the straw. When harvesting begins the stalks and leaves of the rice are still green, in the main, but the head is golden yellow on the terminal two-thirds. The green straw properly cured is a valuable substitute for hay, and is baled and fed to live stock, including the work horses and mules, which become accustomed to it, often preferring it to prairie hay. Harvesting begins in September and continues through October and part of November, often until the 1st of December, and thrashing the rice from the shock begins after it has been allowed to cure and dry for a period of two weeks at least. The machines used are the modern styles of wheat thrashers using steam power, revolving knives for cutting the binding twine, and a blower to remove and stack the straw (Pl. IV, fig. 1). The rough rice as it comes from the thrasher is put in large gunny sacks weighing, when filled, an average of 185 pounds each. The sacked rice is either hauled to the warehouses or direct to the mills (Pl. IV, fig. 2).

RICE PRODUCTS.

The "rough rice" which comes from the thrashing machine consists of the grain proper, which is protected by a closely fitting cuticle hard to remove, and a hard, rough, and brittle husk largely composed of silica, which is easily removed. The husk is first removed by revolving millstones, and the cuticle is removed either by a mortar and pounder or a machine called a "huller," consisting of a cast-iron cylinder with a revolving shaft passing through it from end to end. Both shaft and cylinder are supplied with projecting ribs, which remove the cuticle from the rice. The products of this machine are rice bran, some flour, and clean rice, consisting of entire grains, called "straight-head rice," and grains broken into various sizes. This cleaned rice is not ready for marketing, but later passes through a polishing machine, which gives it a highly finished surface and a pearly luster. The finished product is then passed over screens or perforated plates and sorted into different grades, of which the unbroken or "straight-head rice" forms the first grade, and brewer's rice the last, there being two or three intermediate grades, depending upon the size of the broken grain. The appearance of rice from the rough condition to the finished product, including red rice, rice flour, rice bran, and ash from rice mills, is shown in Plates V and VI. The frontispiece exhibits a stool of Honduras rice, reproduced from a photograph, as the same appears when ready for the reaper and binder. The illustration shows the great productiveness of this cereal, there being 26 stalks and as many heads of rice, all from a single seed. The character of the root of the plant is also shown. These rice stalks stood about 3½ feet high in the field. Japan rice, the other variety raised by prairie-land rice growers, is even more productive than the Honduras, although the grain is appreciably smaller; 50 to 80 stalks and heads from a single seed is not uncommon in a field of Japan rice.

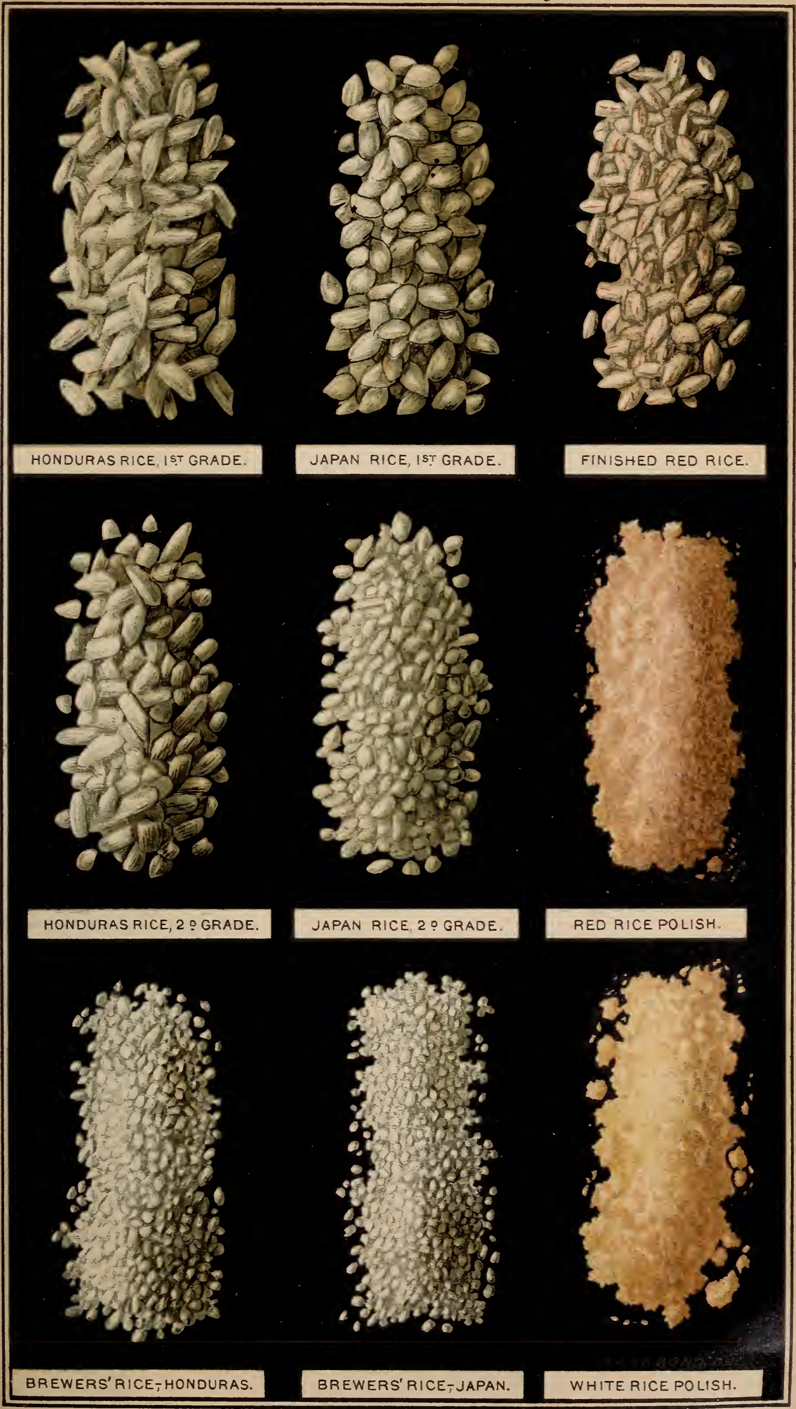
FIG. 1.—THRASHING RICE, MOORE-CORTES PLANTATION, BAY CITY, TEX.

FIG. 2.—RICE MILLS AT CROWLEY, LA.



JULIUS BIEN & CO. LITH. N.Y.

RICE PRODUCTS IN DIFFERENT STAGES.



JULIUS BIEN & CO. LITH. N.Y.

RICE PRODUCTS IN DIFFERENT STAGES.

MEASUREMENTS OF WATER USED.

THE RAYWOOD PLANTATION.

The large rice plantation at Raywood, Tex., was selected as a place to carry on measurements of water used in irrigation of rice for the reason that it was centrally located in the rice-growing district of Texas, and the climate, rainfall, and soil were typical of that district. According to the Southern Pacific Railroad survey, Raywood is 67 feet above the Gulf of Mexico, whose shore line lies about 40 miles to the south. The larger part of the land devoted to rice growing is between 60 and 70 feet above the Gulf. This enterprise was started in 1900, but unavoidable delays prevented the establishment of the pumping plants in time to utilize them that year. About 5,000 acres of rice were planted, however, and, with the rainfall of an extraordinarily wet season, a successful crop of Providence rice was raised, averaging about 7 sacks per acre.

It would appear from the success reached in 1900 that the soil and climate of this section of Texas are peculiarly adapted to rice growing, but it is recognized that the rainfall of that year was exceptionally large for the district and can not be depended upon to raise crops continuously. The soil, however, is certainly typical of the rice district, consisting of a black loam a foot or more deep, intermixed with dark clays which become more pure with depth. This clay is practically impervious to water, the canal levees, except where the so-called joint clays are used, exhibiting the dry exterior slopes characteristic of the most favored Louisiana districts.

THE RAYWOOD CANAL.

The main canal of the Raywood Rice, Canal, and Milling Company begins on the left bank of Trinity River about 11 miles southwest of the railroad station (Pl. VII). For a distance of 7 miles it passes through a heavily wooded region. There are, however, many open tracts and other areas covered with second-growth trees which now occupy lands cleared and cultivated in cotton prior to the civil war, but which have been abandoned from thirty to forty years. This main canal is 150 feet wide between the levee centers for a distance of 4 miles to the second lift, and 100 feet wide from the second lift to a point about 1 mile beyond the third lift. There the canal divides into three main branches, each 80 feet wide, and continuing in the aggregate for about 12 miles. There are about 20 miles of main laterals distributing the water from the canals.

THE PUMPING MACHINERY.

At the head of the canal on Trinity River are located the main pumps of the company (Pls. VIII and IX). Two other pumping plants almost exactly similar, both as to style and capacity, were

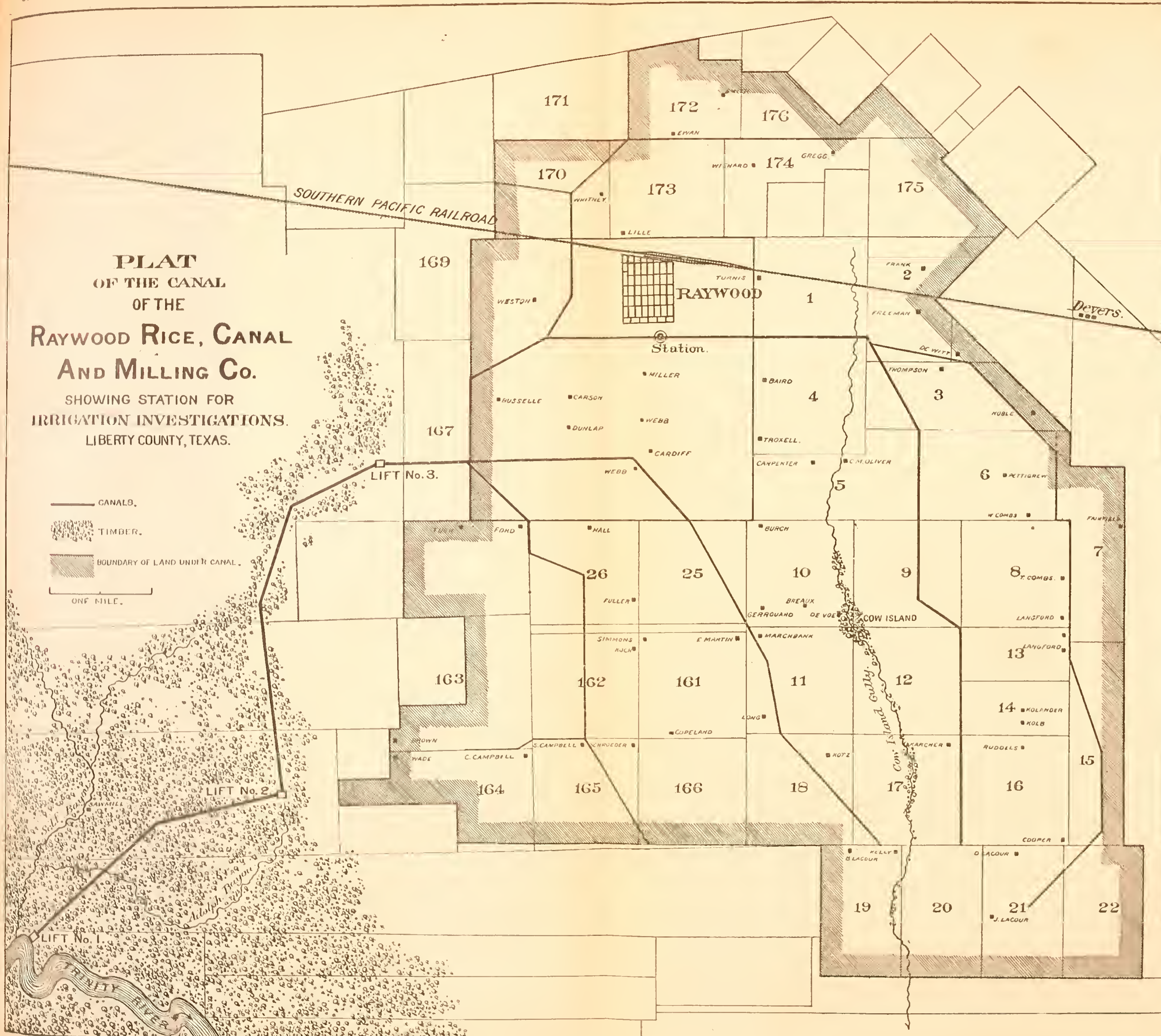
erected at 4 and 7 miles from the river, respectively. There are two pumps at each lift having a stated capacity which ranges between 45,000 gallons and 58,000 gallons per minute, depending upon the speed at which they run. Careful measurements of the discharge of the pumps, using a current meter in the flumes, gave 30,967 gallons per minute when the speed averaged 51 revolutions per minute and 51,509 gallons per minute when the speed averaged 70 revolutions per minute. There is no distribution of water between the first and third lifts, which accounts for the fact that the size and capacity of these three lifts are uniform. Upon the north lateral a smaller plant was established in June, 1901. This consists of one small vertical centrifugal pump run by a 30-horsepower farm engine, which lifts the water 7 feet.

The water is lifted 16 feet at station No. 1, on the Trinity River; 22 feet at station No. 2, 4 miles away; and 27 feet at station No. 3, 3 miles from No. 2—a total lift of 65 feet for all of the water used in rice irrigation at Raywood. The additional lift of 7 feet on the north lateral brings the total lift of water used from that lateral up to 72 feet. This is the highest lift that was noticed in the rice districts.

DUTY OF WATER.

The instruments used to determine the duty of water in rice growing at this station were placed upon a small tract containing 37.96 acres of land. The middle branch of the main canal, 80 feet wide at the point of diversion, was tapped by a small flume 2½ feet wide and 40 feet 6 inches long. The levee, which is 3½ feet high, was cut and aprons of sheet piling drawn through the levee and into the virgin soil. These aprons furnished ample provision against leakage and wash at the sides of the flume. A standard water register was used to keep a continuous record of the depth of the water passing through the flume and the times when water was applied to the rice.

The evaporating tank was established in such manner as would reproduce conditions which prevailed in the rice field. It was set in a pit and partly filled with soil. Water was then poured in until its level was about 4 inches above the surface of the soil. About 1 foot above the water surface in the tank a light wire netting was placed horizontally, being stretched over a square frame which rested upon posts at the corners. The wire screen was used as a support for grasses and rice straw, which were increased in quantity as the rice matured in the field, so that the depth of shade cast over the water by the growing rice was reproduced, as nearly as possible, in the tank. There is no question whatever that the evaporation from a tank placed upon the top of the ground and exposed to the direct rays of the sun would be far greater than that shown in this experiment and the one made at Crowley, La.


PLAT
OF THE CANAL
OF THE
RAYWOOD RICE, CANAL
AND MILLING CO.
SHOWING STATION FOR
IRRIGATION INVESTIGATIONS.
LIBERTY COUNTY, TEXAS.
CANALS.
TIMBER.
BOUNDARY OF LAND UNDER CANAL.
ONE MILE.
SOUTHERN PACIFIC RAILROAD
RAYWOOD
Station.
Devers.
LIFT No. 3.
LIFT No. 2
LIFT No. 1.
COW ISLAND
Cow Island Gully
TRINITY RIVER
Adolph Bayou
171
172
176
170
173
174
175
169
167
163
1
2
3
4
5
6
7
8
9
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161
162
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165
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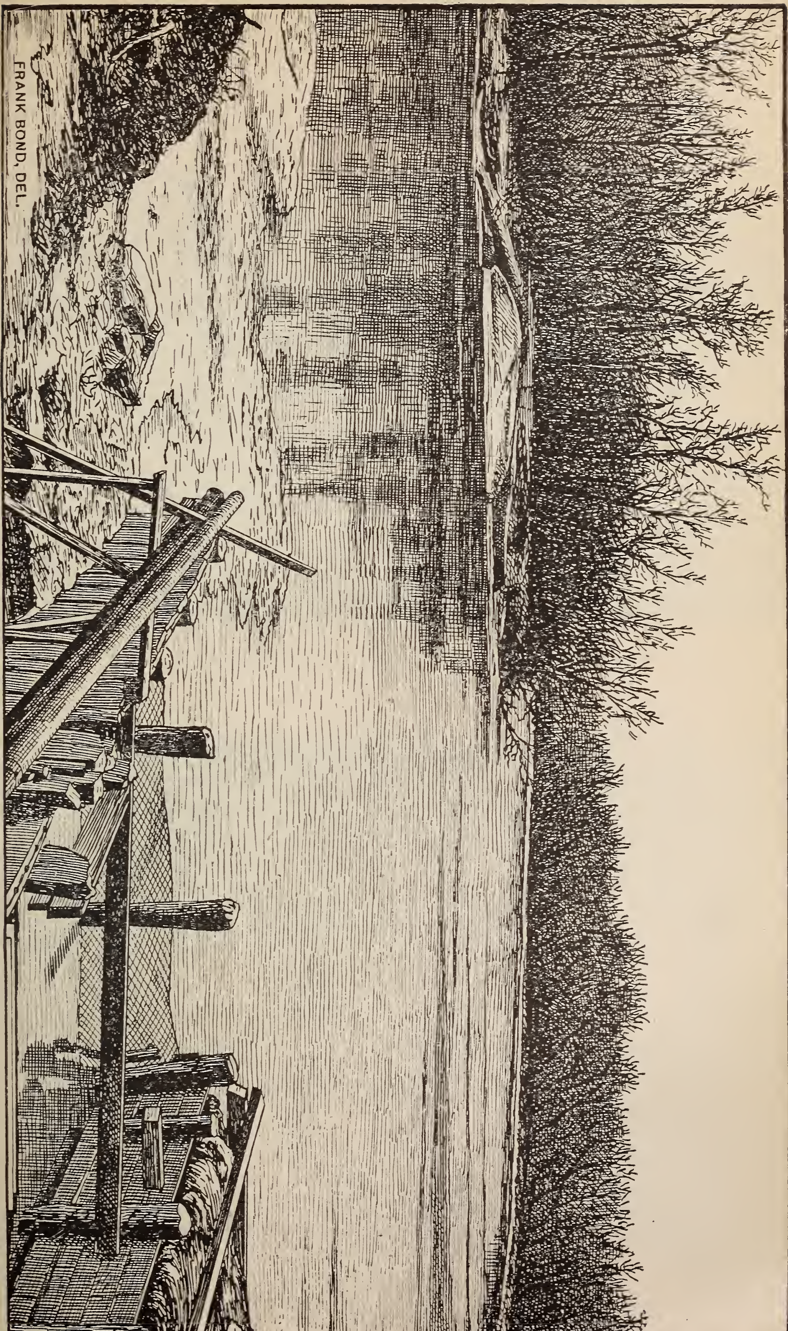
WESTON
WHITNEY
LILLE
EWAN
WISNARD
GREGG
TURNIS
FRANK
FREEMAN
DE WITT
THOMPSON
NOBLE
MILLER
HUSSELLE
CARSON
DUNLAP
WEBB
CARDIFF
BAIRD
TROXELL
CARPENTER
C. M. OLIVER
PETTIGREW
W. COMBS
FAIRFIELD
T. COMBS
LANGFORD
FORD
HALL
BURCH
FULLER
BREAUX
GERROUAND
DE VOE
MARCHBANK
SIMMONS
E. MARTIN
LONG
COPELAND
BROWN
WADE
C. CAMPBELL
S. CAMPBELL
SCHROEDER
KOTZ
MARCHER
RUDDELLS
KOLANDER
KOLB
COOPER
KELLY
B. LACOUR
O. LACOUR
J. LACOUR



BEND OF TRINITY RIVER, TEXAS, SHOWING INTAKE OF RAYWOOD MAIN PUMPS.

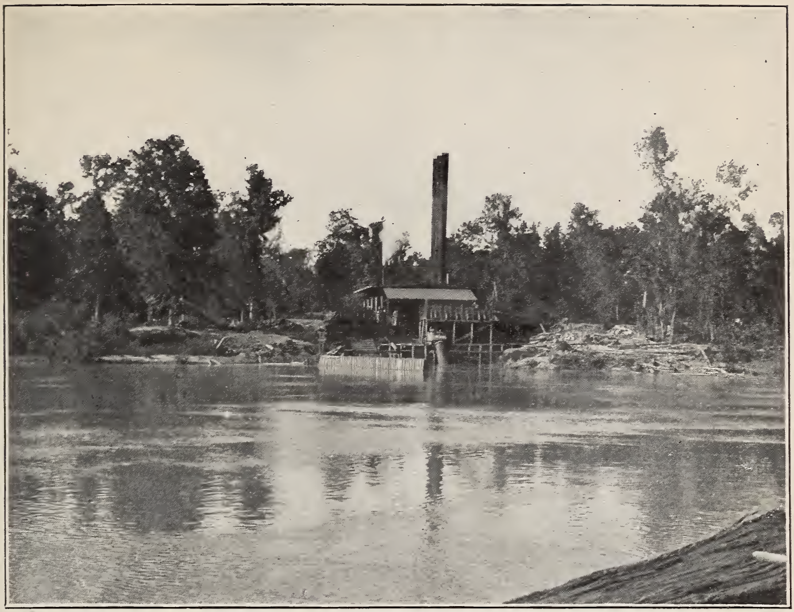


FIG. 1.—MAIN PUMPS, RAYWOOD CANAL COMPANY, LOOKING ACROSS TRINITY RIVER, TEXAS.

FIG. 2.—DISCHARGE OF MAIN PUMPS, RAYWOOD CANAL COMPANY.

TYPICAL TEXAS BAYOU NEAR RAYWOOD, TEX.

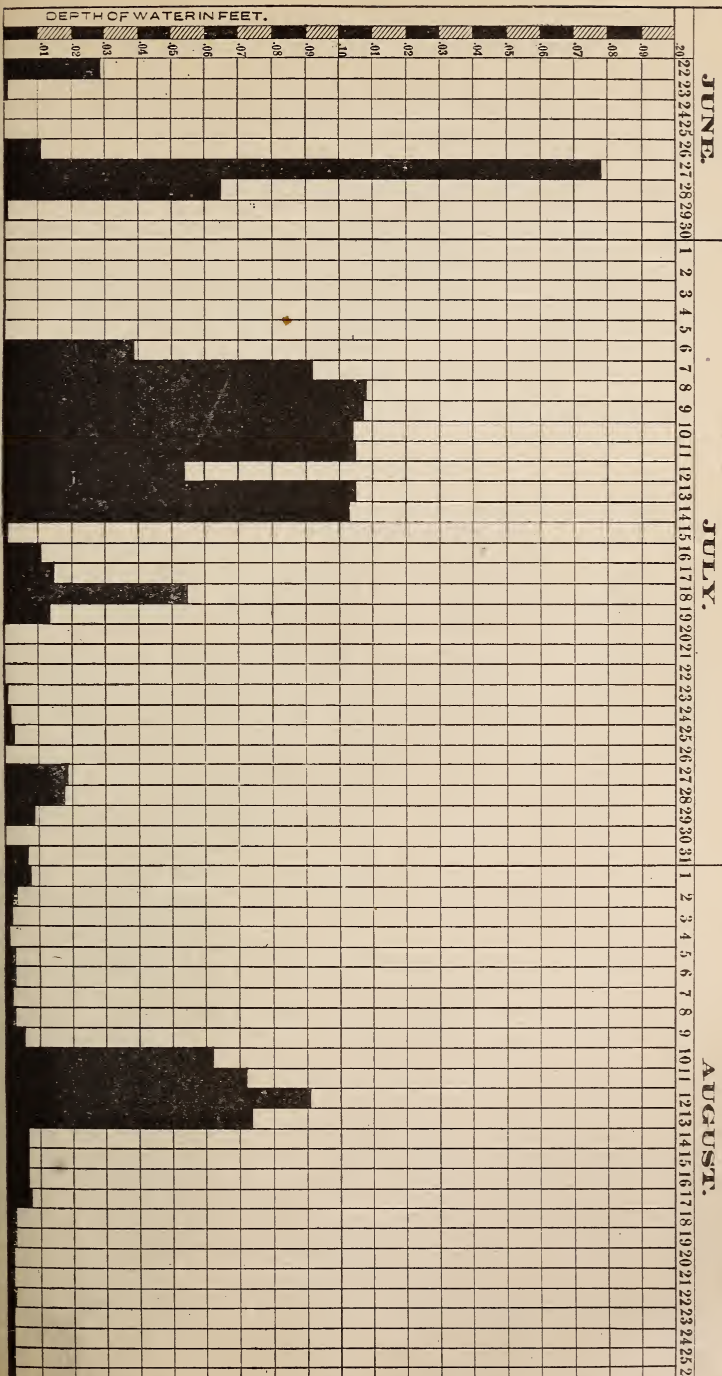


DIAGRAM SHOWING DEPTH OF WATER USED ON RICE FIELD AT RAYWOOD, TEXAS, AND THE DATES WHEN IRRIGATION OCCURRED.

The rain gage was a double tube securely mounted upon a post, the top of the gage being about 4 feet above the ground.

By the means above described, a record of the evaporation, the rainfall, and the times when irrigation took place, was kept. From the continuous record of the depth of water which passed through the flume, kept by the register, the volume of water used on the rice field was determined. These records covered a period of seventy-one days. During this period the experiment field, containing 37.96 acres of rice, received from the canal enough water to cover it to a depth of 19.66 inches, and enough rainfall to cover it to a depth of 9.15 inches. The evaporation during the same period was 16.03 inches, leaving a net depth of water to promote the growth of the rice crop and supply the volume taken up by the soil, amounting to 12.78 inches. The following table shows the water received by the crop during the several weeks of the irrigating season, and the accompanying diagram (Pl. XI) shows the dates of applying water:

Depth of water used on Raywood rice farm and the rainfall and evaporation during the flooding season of 1901.

Week ending—	Flood water.	Rainfall.	Evaporation.
	Inches.	*Inches.*	*Inches.*
June 29, 1901	3.42	0.42	1.90
July 6, 1901	.47	.66	3.36
July 13, 1901	8.10	.36	2.04
July 20, 1901	2.39	2.16	.12
July 27, 1901	.30	1.56	1.20
August 3, 1901	.58	2.70	1.10
August 10, 1901	.96	.96	3.24
August 17, 1901	3.19	.00	1.20
August 24, 1901	.20	.30	1.08
August 31, 1901	.05	.03	.79
Total	19.66	9.15	16.03

Summary showing duty of water under Raywood Canal.

Area irrigated .... acres..	37.96
Depth of water received from irrigation .... inches..	19.66
Depth of rainfall .... do....	9.15
Total depth of water received by the land .... do....	28.81
Evaporation .... do....	16.03
Net depth of water received by the land .... do....	12.78

The method of flooding the field was that which prevails generally throughout the prairie-land rice districts of Texas and Louisiana, the higher cuts being flooded first. An examination of the plat of the experiment field (fig. 6) will make plain the plan of levee construction followed, which varies in different fields both as to area and form of cuts, depending upon the fall of the land.

The farm was planted April 22, and up to June 22, the time flooding from the canal began, a period of two months, the precipitation for

the year was much less than for many years, and the farm, while showing a fair stand of rice, gave certain promise that no crop of Providence rice such as was produced in 1900 was possible. In fact, the rainfall between April 22 and June 22 was barely sufficient to keep the rice growing until the artificial supply of water was furnished. A small farm adjoining the experiment field on the west was reseeded late in June. The precipitation between May 1 and June 22 was 1.48 inches, which was not enough to prevent the rice from turning yellow

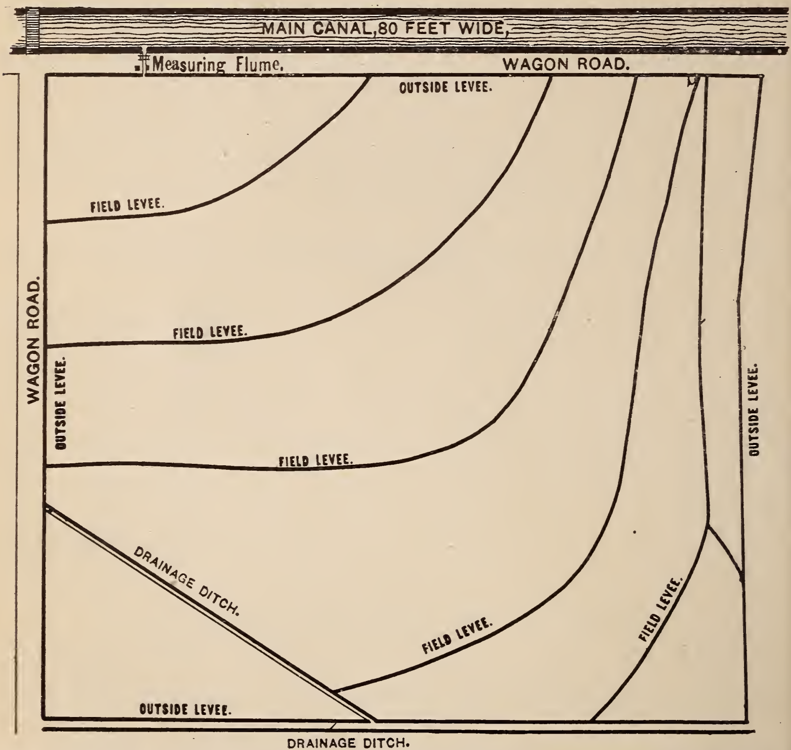
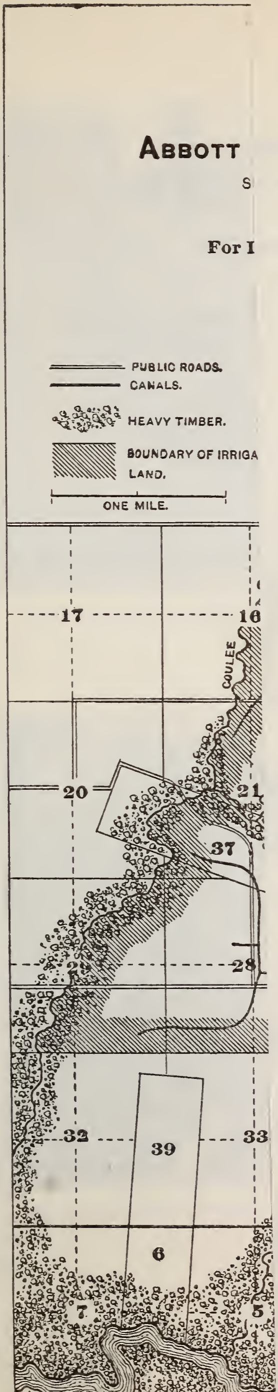


FIG. 6.—Plat of rice field at Raywood, Tex., where measurements were made to determine the volume of water used in irrigation of rice.

and presenting an unhealthy appearance. Had it been possible to irrigate the field three weeks, or even two weeks, earlier, a better yield might have resulted. The actual return from the 37.96 acres, however, was 508 bags, or 13.38 bags per acre irrigated. Considering the conditions which prevailed prior to the application of water, this is a very satisfactory yield, although not so great as on some of the adjoining farms. This difference, however, is partly accounted for by the failure to plant sufficient seed. Less seed was planted on the experiment farm than on any other farm on the plantation.


ABBOTT
S
For I
PUBLIC ROADS.
CANALS.
HEAVY TIMBER.
BOUNDARY OF IRRIGA
LAND.
ONE MILE.
17
16
COULEE
20
21
37
28
32
39
33
6
7
5

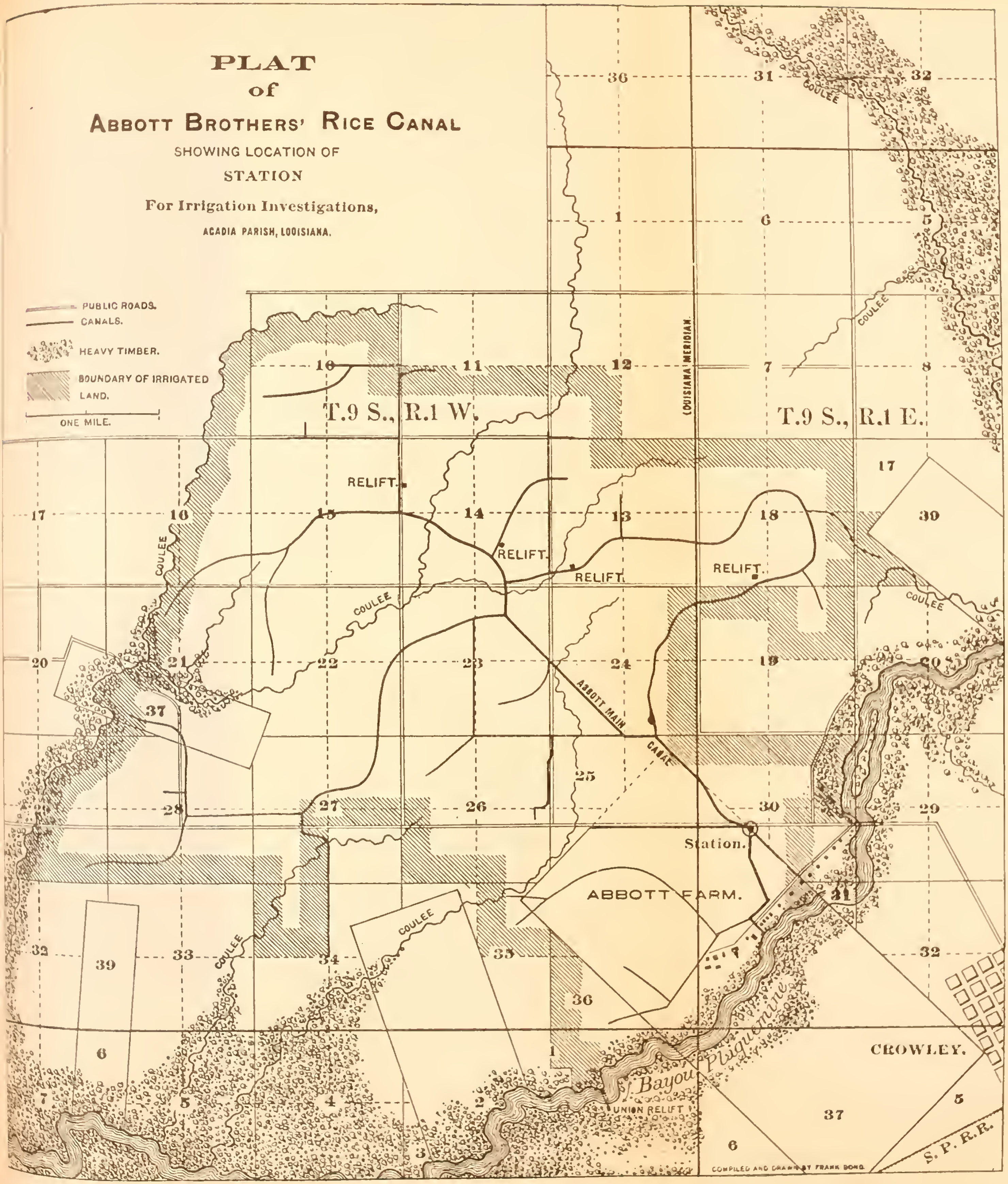

PLAT
of
ABBOTT BROTHERS' RICE CANAL
SHOWING LOCATION OF
STATION
For Irrigation Investigations,
ACADIA PARISH, LOUISIANA.
PUBLIC ROADS.
CANALS.
HEAVY TIMBER.
BOUNDARY OF IRRIGATED LAND.
ONE MILE.
T.9 S., R.1 W.
T.9 S., R.1 E.
LOUISIANA MERIDIAN.
RELIFT.
COULEE
ABBOTT MAIN CANAL
Station.
ABBOTT FARM.
Bayou Plaquemine
UNION RELIFT
CROWLEY.
S. P. R.R.
COMPILED AND DRAWN BY FRANK BOND.

FIG. 1.—INTAKE OF MAIN PUMPS, ABBOTT BROTHERS' PLANT, BAYOU PLAQUEMINE, LOUISIANA.

FIG. 2.—RACEWAY OF MAIN PUMPS, ABBOTT BROTHERS' PLANT, BAYOU PLAQUEMINE, LOUISIANA.

THE ABBOTT BROTHERS' PLANTATION.

The business of prairie-land rice growing had its beginning upon the spot now occupied by the main pumps of Abbott Brothers, about 2 miles northwest of Crowley, La., and the main canal of this farm occupies the same right of way as that canal which first carried water from the Bayou Plaquemine to the experimental rice field in 1894. (See map, Pl. XII.) The Abbott farm is the pioneer rice farm of the district, and what has already been stated as to the experiments made there need not be repeated. It is sufficient to say that it was to this farm and these men—the Abbott Brothers and their associates—who had the courage to carry on original experiments there, that credit belongs for organizing an agricultural industry of great concern to the people of the United States. The rice lands around Crowley are typical of the upland prairie regions of that section of Louisiana, and the Abbott farm is set in the midst of this district. The soil is a rich black loam which is impervious to water, and apparently capable of continuously raising crops of rice without marked diminution of the yield. After continuous cropping with rice for a period of six years, the shortage in yield of the present year was laid to the insufficiency of the water supply and the use of brackish water after the middle of July. There is little doubt, however, that a rotation in crops will benefit the Louisiana rice growers, and the plan will be put into practice on the Abbott farm. The source of water supply, the Bayou Plaquemine, appears to be overappropriated, and the effect upon the yield of the Abbott farm in a dry year is of serious concern to the owners. But this subject is discussed at length elsewhere in this bulletin.

THE ABBOTT PUMPING MACHINERY.

The main pumping station consists of one 16-inch and two 18-inch centrifugal pumps (Pl. XIII), with rope transmission, driven by two 125-horsepower engines and one engine of 100 horsepower. The lift of these pumps is from 18 to 24 feet, depending upon the stage of water in the bayou, and is a characteristic high lift of the rice district. Four small relifts of 4 feet each are located along the main canal and laterals from 3 to 4½ miles, measured along the canal, from the main pumps. The entire lift is, therefore, 28 feet. This is one of the highest lifts on the Bayou Plaquemine.

THE ABBOTT CANAL.

The main canal, the laterals, and all distributing ditches are located in the open prairie, and canal construction is of the simplest possible character throughout. The main canal is 40 feet wide between levee centers, and continues for about 4 miles, when it divides into two main branches, and these branches continue, one about 3 miles and the other

about 4 miles farther. Water distribution by laterals begins about 250 yards from the main pumps. The land on both sides of the canal is planted in rice for a distance varying between one-fourth of a mile and 3 miles. The total area of rice irrigated in 1901 was 7,090 acres.

DUTY OF WATER.

The instruments and apparatus used upon the Abbott farm for measuring the volume of water used upon a surveyed field of rice, and for determining the evaporation and rainfall during the irrigating season, were located upon the main canal about three-fourths of a mile from the main pumps, as shown on the plat of the canal (Pl. XII).

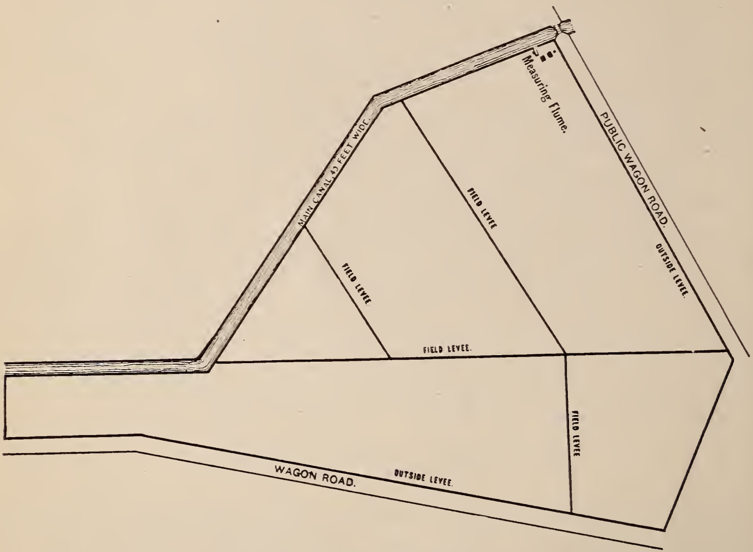


Fig. 7.—Plat of rice field at Crowley, La., where measurements were made to determine volume of water used in irrigation of rice.

The tract of land selected was one which had raised rice continuously for six years or more, and contained 37.44 acres.

This tract is irregular in outline (fig. 7), the character of the soil is typical of the farm and region, and diversion of water from the canal was easy. The levee, which is about 3 feet high at the station, was cut and a well-constructed flume 4 feet wide and 16 feet long carried the water from the canal to the experiment field. Wing aprons of sheet piling were driven in to prevent leakage and consequent wash. A water register was placed on this flume, and a continuous record of the depth of water passing through the flume was kept during the irrigating season. Near by a double-tube rain gage, set 4 feet above the ground, and an evaporation tank were established. The evaporation tank was protected from the direct rays of the sun in the manner

UNLOADING WOOD, ABBOTT-DUSON PLANT, BAYOU DES CANNES, LOUISIANA.

described and for the reasons set forth in the description of the apparatus used at Raywood, Tex. The period between the date when the water was first turned through the flume and when the levees were cut to drain the field for harvesting embraced seventy-nine days, although the first and last irrigation, as appears from the diagram showing depth of water and dates of flooding, were June 28 and August 12, respectively, a period of forty-six days only (fig. 8).

The result of the measurements is somewhat surprising. The generally accepted idea that enormous volumes of water are needed to irrigate rice and that evaporation is excessive along the Gulf coast does not appear to be supported by the facts. It was not possible to estimate the mean depth of water on the field when the levees were cut, but it must have been considerable, and the depths given below should be reduced slightly on this account. The table which follows shows the depth of water received by this crop during growth, together with the loss of water by evaporation:

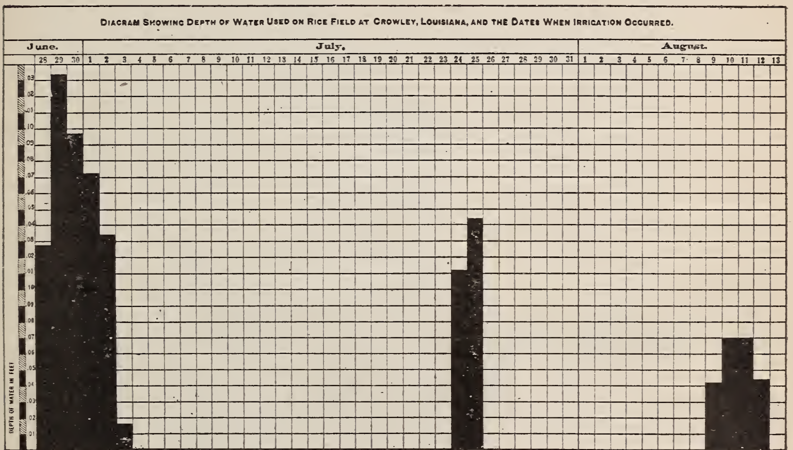


FIG. 8.—Diagram showing depth of water used on rice field at Crowley, La., and the dates when irrigation occurred.

Depth of water used on Abbott Brothers' rice farm, and the rainfall and evaporation during the flooding season of 1901.

Week ended—	Flood water.	Rainfall.	Evaporation.
	Inches.	*Inches.*	*Inches.*
June 29, 1901	4.46		
July 6, 1901	6.23	4.08	3.24
July 13, 1901		.48	2.04
July 20, 1901		.17	2.23
July 27, 1901	3.07	1.21	2.28
August 3, 1901		1.08	1.56
August 10, 1901	1.34	.32	.72
August 17, 1901	1.37		.24
August 24, 1901		1.86	1.68
August 31, 1901		.84	.48
Total	16.47	10.04	14.47

Summary showing duty of water under Abbott Canal.

Area irrigated	acres	37.44
Depth of water received from canal	inches	16.47
Depth of rainfall	do	10.04
Total depth of water received by land	do	26.51
Evaporation	do	14.47
Net depth of water received by land	do	12.04

By reference to the summary above it will be seen that the rice field of 37.44 acres received from the canal during the flooding season 16.47 inches of water, and precipitation amounting to 10.04 inches, a total of 26.51 inches. The evaporation during the same period was 14.47 inches, leaving a net depth of water of 12.04 inches. A comparison of these figures with those obtained at Raywood, Tex., shows a coincidence in final results that was hardly anticipated. The depth of water supplied by the pumps at Raywood, Tex., was 3.19 inches greater than that used on the Abbott farm at Crowley, but at Raywood the rainfall was only 9.15 inches, while 10.04 inches fell at Crowley, being 0.89 inch in favor of Raywood. The evaporation at Raywood was 1.56 inches greater than on the Abbott farm, so that the final figures showing net depth of water used to grow and mature the rice crops at the two stations are 12.04 for the Abbott farm at Crowley and 12.78 inches for the Raywood, Tex., farm, a difference of 0.74 inch only.

PUMPING PLANTS ALONG BAYOU PLAQUEMINE.

Bayou Plaquemine is a water course typical of the rice districts of southwestern Louisiana. It rises in the southern part of St. Landry Parish, and after flowing about 10 miles enters Acadia Parish, which it crosses from the northeast to the southwest. The length of the bayou, as measured upon the map, approximates 45 miles, but a meander of one of its banks would, undoubtedly, give it many times that length, so undecided as to pathway was the surplus water that first sought this outlet to the Gulf. The waters of the bayou run deep, especially along the lower reaches, and are full of silt, and its current is comparatively sluggish. Its depth varies greatly during the year; but the effect of the rice pumps in causing a reversion of the current, and the advent of brackish and salt water in the race ways, forced the conclusion that the tide water of the Gulf of Mexico, even during ebb, is considerably above the bottom of the stream. The drainage basin of the bayou embraces, approximately, 330 square miles of territory, an area both greater and less than that drained by other bayous and streams in the rice district. Considering its source of supply, its length, the volume of its discharge, and the topographical features of the country traversed, the bayou presents no peculiar

VINEYARD & WALKER PUMPS, EAGLE LAKE, TEXAS.

characteristics. Easy diversion in comparison with what obtains along many streams may have recommended it to those who made the first experiments in flooding elevated rice fields. The majority of the main pumps drawing upon its supply do not lift the water more than 20 feet, the highest lift being 28 feet. The banks of the main bayou, and of its principal tributaries as well, are deeply wooded for a distance on both sides varying from a few yards to a mile or more, and the water glides along, going or coming, from early spring until late autumn, in perpetual shade.

The bayou, whose capacity was increased in 1901 to the limit of existing artificial means to augment its supply, furnished water sufficient to mature 45,510 acres of rice. The water for this large area was taken directly from the bayou, and the canals which supply the farms embraced in the tract have no other source of supply than the regular flow of the bayou to or from the Gulf. That is to say, the main pumps in no case drew water from reservoirs made by dams across the bayou constructed for the purpose of impounding providential rains. An additional area of 2,675 acres was partially watered from the regular flow of the bayou, but an increased volume was obtained by constructing dams, either across the main bayou, or some tributary of the same, thus holding back the supply produced by rainfall during the flooding season. The total area of rice irrigated within the drainage basin of the bayou was 48,185 acres.

The demand made upon the Bayou Plaquemine is already greater than it can supply. Sixteen pumping stations, which are not dependent upon rains of the flooding season for their supply of water, and six others which place much dependence upon such supply, are established along the bayou or at short distances above the mouths of its tributaries. Of these irrigation plants, 5 are large and public in character, their owners supplying water and leasing land to farmers under their canals. The remainder are small plants, comparatively, and water only land owned or controlled by their owners. Beginning with the plant nearest the mouth of the bayou and going upstream the pumping stations are as follows:

Paul Fremo, with pumping capacity for 300 acres of rice, raised 200 acres in 1901; R. L. Wainright, above Fremo, 50 acres; P. D. Wilder, next in order, 250 acres; Felix Loplot, 350 acres; Fremo Istre, 965 acres. Each of these men has put in a 10 or 12 inch centrifugal pump, and all take the water directly from the bayou, which is wide and deep here.

Next above Fremo Istre's pump is the large plant of the Midland Canal Company, Limited, which was begun in 1889 and has since been completed, with a pumping capacity of 40,000 gallons per minute. This company has two 18-inch and one 13-inch pumps, with an estimated irrigation capacity of 5,000 acres. Four thousand acres of rice

were raised by the company this year. The water is distributed through 8 miles of canals and laterals. The water lift is 20 feet.

The small rice farms of Roller & Freeland and Abbott, Frankel & Slocum lie between the Midland Canal and that of the Miller-Morris Company, the next large plant on the bayou. The Roller-Freeland plant consists of one 18-inch centrifugal pump, which watered 1,050 acres this year. The single 16-inch pump of Abbott, Frankel & Slocum watered 1,500 acres, and the J. J. Thomas farm, next above the Miller-Morris Canal, succeeded in raising 730 acres.

The large plant of the Miller-Morris Canal Company, Limited, is about 4 miles above the Midland Canal. The plant was established in 1897–98, beginning operations the latter year. Its lifting capacity is now stated to be 100,000 gallons per minute, three new pumps having been installed the present year. The lift of these pumps is 20 feet, and the water is distributed through 25 miles of main canals and laterals.

The irrigation pumps of the Roller Canal Company, Limited, are about 3 miles above the Miller-Morris Canal. This company began with a single pump in 1897, but now has three 18-inch centrifugal pumps with a stated capacity of 45,000 gallons per minute. The lift of these pumps is 24 feet, and the water is discharged through 8 miles of canals and laterals. The irrigation capacity of the plant is placed at 8,000 acres.

The small pump of J. F. Naftel is established upon the bayou between the Roller pumps and those of the Abbott Brothers, the next large plant above. Dr. Naftel irrigated but 400 acres in 1901.

The large pumping station of Abbott Brothers is just a few rods above Dr. Naftel's pump and has already been described under the topic "The Abbott Brothers' plantation."

About one-half mile above the main pumps of Abbott Brothers is located the main pumping station of the Crowley Canal Company, Limited. This was the first public plant in the rice district, its owners and promoters, the Duson Brothers, having erected it for the purpose of leasing to farmers water and land for rice growing. It was erected in 1896, the year which witnessed the first unqualified success in rice irrigation on the Abbott plantation. The present lifting capacity of the Crowley Company's pumps is stated at 60,000 gallons per minute. There are 12 miles of main canals and laterals, and the irrigation capacity is 11,000 acres. Seven thousand five hundred acres were watered in 1900 and 10,350 acres the present year. The lift of the pumps is 20 feet.

The remainder of the pumping plants on the Bayou Plaquemine are private enterprises wholly, and operate but a single pump each. Two or three of them are not directly located upon the bayou, but upon small tributary bayous or coulees. As already noted, they

FIG. 1.—PUMPING STATION, MOORE-CORTES CANAL COMPANY, BAY CITY, TEX.

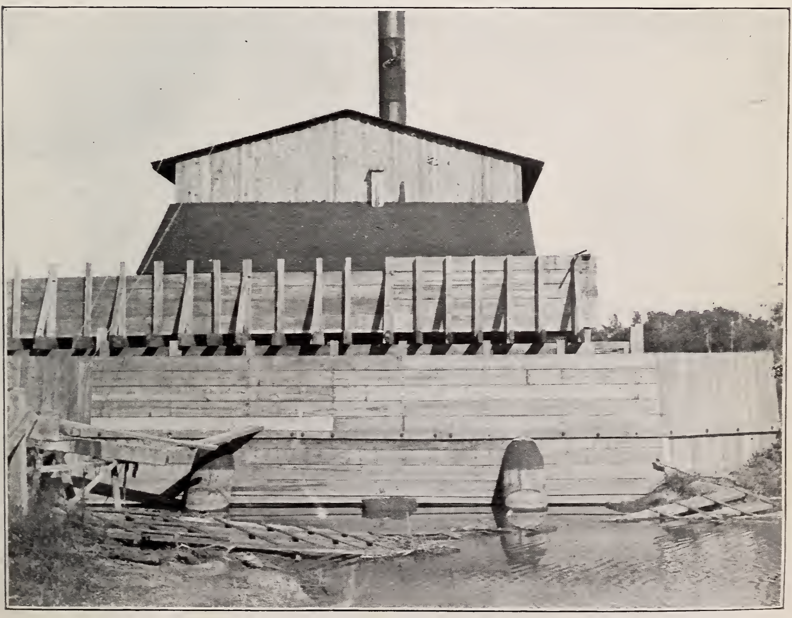


FIG. 2.—INTAKE OF PUMPS, MOORE-CORTES CANAL COMPANY, BAY CITY, TEX.

depend partly upon rainfall during the flooding season for their water supply. The first of these plants is the Green-Shoemaker plant, having a 12-inch pump. Four hundred and fifty acres were planted this year (1901), but failure of the water supply caused 275 acres to be turned over to the Abbott Brothers for irrigation. Green and Shoemaker have the first dam across Bayou Plaquemine, put in to hold back surface water from passing rains.

David Gow, who has a small pump a short distance above the Green-Shoemaker plant, planted 475 acres of rice this year, but failure of the water supply forced him to abandon 175 acres. Mr. Gow has a high dam across the bayou to impound surface water during the season of irrigation.

About two miles above the Gow pump Robert McCormick has a small pumping station. It is located upon a tributary coulee called Long Point Bayou and consists of one 10-inch centrifugal pump. Four hundred acres, which is about one-fourth more than the plant can handle during an average year, were planted in 1901. The dry season compelled the surrender of 200 acres of this area to the Abbott Brothers for flooding. Mr. McCormick watered 65 acres for a neighbor, making a total of 265 acres watered by the McCormick pump.

The Bayou Plaquemine is again dammed to make a reservoir for the Duson-Shaffer pump, an 18-inch centrifugal, located about 2 miles above McCormick. Duson and Shaffer planted 700 acres this year. On a small tributary coulee a little farther up W. S. Hurlbert has a dam and a small pump. Mr. Hurlbert planted 300 acres this year.

The last pumping plant upon the Bayou Plaquemine and tributaries is located upon Bayou Wykoff, a small tributary. It is owned by Messrs. Roller and Freeland, who have dammed the bayou and who planted 100 acres of rice in 1901.

The above data was furnished by the companies or individuals in interest. The capacities of the pumps, in all cases, are those given by the owners, few extended or careful measurements of their discharges having been made. It will be safe to assume that the results given are those obtained under more favorable conditions. Measurements of flume and canal flow were made by the writer when very low water prevailed in the bayous, and the danger of pumping air was always present. In addition the pumps were run at a safe instead of a maximum speed. Under these conditions careful measurements by current meter gave from two-thirds to three-fourths the capacity of the pumps, as stated above. A safe estimate of the actual and continuous demand upon the bayou during the flooding season of 1901, a period of one hundred and ten days, is 275,000 gallons per minute. This is but four-fifths of the discharge of the bayou at the time the same was gaged in March, but is greatly in excess of the discharge during the flooding season of an average year. In fact, a discharge from the

bayou sufficient to meet this demand seldom occurs during the flooding season.

A study of the volume of water supplied by the bayou, based upon measurements of discharge, shows a great variation, especially during a dry year. Early in March, 1901, the bayou was gaged at the bridge opposite Cane Island, a point just below the Union Relift, hereinafter described, and found to be discharging 767 cubic feet per second, or 344,230 gallons per minute. At this time not only were the banks full, but the water overflowed a considerable extent of country on either side. The high water appeared at that time to be at its maximum. Thenceforward the water rapidly receded until extreme dry-weather conditions prevailed, when the irrigation pumps were started. Accessions to the volume of water in the bayou between the Union Relift and its mouth are practically confined to the surface supply, which, of course, fluctuates with the rainfall.

The starting of the large pumps was marked by a phenomenon characteristic of the districts where rice is grown, but not possible elsewhere. The current of the bayou set backward. Instead of flowing toward the Gulf of Mexico to drain the country, it flowed from the Gulf of Mexico to flood the fields of rice. No stronger testimony that the natural supply of water in the bayou was dangerously low could be offered than this phenomenon, which gave promise that unless weather conditions greatly improved, as viewed by the rice grower, the extra large crop of rice generally anticipated would not be harvested.

PLAN TO AUGMENT THE SUPPLY.

The year 1897 was also a dry year, comparatively speaking. The certainty of an insufficient supply of water to irrigate the rice sowed under the Abbott, Crowley, and Roller canals, led the managements of these enterprises to unite in a plan to increase the volume of the bayou. Experience had shown that unless the season's rainfall was equal to, or even above, the average, one or all of these plantations would be compelled to reduce the acreage planted. The plan, as matured, called for the construction of a pumping plant on the bayou below the plants of the Abbott, Crowley, and Roller canals, and having a capacity equal to or greater than that of all three combined. The pumping station called the "Union Relift" was the result. About a half mile below the main pumps of the Roller Canal, and at the extremity of a loop in the meandering bayou, a well-constructed pile dam was put in. This dam, when used, raises the level of the water about 40 inches. For the purpose of controlling the flow of the bayou a canal was cut across the neck of the loop and a gate put in. The capacity of the plant is stated as 334 cubic feet per second, or 150,000 gallons per minute. During the periods of low water, when the pumps of the three upper stations would be unable to get a sufficient

ELECTRIC PUMPING PLANT ON EAGLE LAKE, TEXAS.

supply of water for the needs of the rice under their canals, and especially during a season like that of 1901, when their supply would be cut off altogether, this supplemental pumping station has been of very great value to its promoters. It was operated continuously for the last six weeks of the flooding season in 1899, the year it was completed. In 1900 the pumps were run for eight days only, and during 1901 for the entire irrigating season. In its work of reversing the current of the bayou the Union Relift was aided, of course, by the pumps of the Midland, Miller-Morris, and other plants below, their combined effort causing the junction of the bayou Plaquemine with the Mermentau River to present the appearance of an outlet instead of an inlet.

Even under a permanent condition of maximum precipitation for this district, such as obtained in 1900, successful irrigation of all the rice land within reach of the various canals would be impossible, for the available acreage is far in excess of that irrigated to-day. During such years, however, a maximum acreage will be planted and a maximum harvest reaped, but the experience of the past four years does not justify the belief that the maximum acreage planted in any future season, under prevailing conditions, will greatly exceed that of the best year of the past. In other words, the capacity of the bayou is already reached unless the duty of water in rice irrigation can be increased.

THE EFFECT OF A DRY SEASON.

The experience of a dry season may be briefly told. It is the experience of 1901. The probability of insufficient water for a large acreage of rice along the Bayou Plaquemine was indicated by the drought during the early part of the planting season. The period of scant precipitation of April and May was prolonged and the drought was fairly under way before flooding began. But the actual presence of a dry season was not sufficiently impressed upon the minds of the farmers to cause a restriction in the acreage planted. In fact, most of the farmers planted greater areas in rice than ever before. As the season advanced the capacity of the bayou was strained to the utmost to keep the pumps at work. From day to day the slight fluctuations in the water level were closely watched as well as the discharge from the flumes, and the latter undoubtedly varied with the depth of water above the intake pipes of the pumps. So shallow did the water become at the latter points that whirlpools, into whose open funnels the eye could penetrate one or two feet or more, were a common sight, and the taking of air by the pumps diminished their discharge materially. The final result of the dry season may be summed up in a few words: The small planters farthest up the stream were first forced to abandon portions of their crops of rice in its various stages of advancement, and the

large planters were compelled to use the utmost economy in the distribution of the available supply. While the demands of the lessees of water under the canals were persistent and vigorous, many rice fields which needed water badly were compelled to await their turn, and this sometimes was delayed ten days or two weeks beyond the time when the water would have done the most good. The area abandoned meant a loss varying between 10 and 14 sacks of rice per acre.

The insufficient water supply necessarily meant reduction in yield and this reduction was further augmented, in some degree, by the invasion of salt water which followed the withdrawal of the fresh water from the bayou. On July 15, salt water showed its presence on the steam gages and cocks of the boilers from one end of the bayou to the other, and while the great body of rice was far enough advanced to survive the injurious effects of the salt water, some fields were too young to do this and were greatly injured. Some of the rice growers were exceedingly diffident about making estimates of their probable losses from the two causes mentioned, but others were quite otherwise. In spite of the appearance of their fields some said there would be no loss whatever. On the other hand, Abbott Brothers stated that their loss this year would reach at least one sack per acre in the fields which were watered as regularly as the supply would permit. The Roller Company, owning the next large plant below the Abbott plant, estimated its loss at 2 per cent. These figures vary greatly, and if that of the Roller Company is taken as representing a fair average for the whole bayou district, the net loss, including the shortage from acreage planted but actually abandoned, would reach $37,000. If the larger estimate is correct, the loss due to inadequate fresh-water supply and consequent use of salt water, would reach $145,000 at least. While it was not possible to get exact statistics as to the yield last year, all of the rice growers agreed that the average was ten sacks per acre. Manager Adams, of the Midland Canal Company, stated that in 1900 the yield from 3,500 acres under the Midland Canal was 58,881 sacks, which is 16.8 sacks per acre. David Gow raised an average of 13 sacks and Robert McCormick 11 sacks. Exact figures could not be obtained from the other planters. The Miller-Morris manager did not have the returns for the reason that the management had changed hands, but he stated that the yield probably averaged 10 sacks. The Abbott, Roller, and Crowley managers gave 10 sacks as their average, and there is no doubt that 10 sacks per acre is low enough for the average yield of last year. An effort was made to get exact statistics of the crop raised in 1901, but it was unsuccessful. Some of the farmers were diffident about making public their exact crop returns, fearing, doubtless, that publicity might injure them, especially if the partial failure was due to drought and consequent use of salt water. Returns were promised, but, excepting in a few cases, were not received at the time it was desired to print this report.

WATER RIGHTS IN LOUISIANA.

The irrigation industry in the rice districts is confronted with the fundamental question of the control and division of the public water supplies. Because the industry is new in Louisiana this question has received as yet but little consideration there. The industry has developed so rapidly during the past decade, however, that millions of gallons of water are being drawn from the streams of this section every minute of time during a third of the year, and it is believed that it will add to the stability of the rice-growing industry if water rights can be placed on a firm foundation.

CONSTITUTIONAL PROVISIONS.

An examination of the constitution of Louisiana reveals only one article bearing on the subject of water titles. This is article 290, which declares:

Riparian owners of property on navigable rivers, lakes, or streams within any city or town in this State having a population in excess of five thousand shall have the right to erect and maintain on the batture or banks owned by them such wharves, buildings, and improvements as may be required for the purpose of commerce and navigation, subject to the following conditions, and not otherwise. * * *

Although the rice grower began to draw water from Louisiana streams and bayous for the irrigation of rice nine or ten years before the constitution of 1898 was adopted, the influence of adequate water laws on the prosperity and stability of this great industry does not seem to have been considered at that time.

STATUTORY PROVISIONS.

The statutes of the State contain brief mention of the appropriation of water for agricultural purposes. They do not, however, in definite terms, authorize it. Section 1 of act No. 26, 1896, provides redress against the consumer of water for irrigation who neglects to meet his obligation to the canal owner for the supply furnished. The words of the statute are as follows:

Any person, association of persons, or corporation who shall furnish water to another for the purpose of aiding or assisting him in the growing or maturing of a crop shall have a privilege coequal with the privilege for supplies upon said crop to secure the payment of the agreed compensation therefor.

Although the irrigation of rice is not mentioned in this section, it appears evident that the section was designed for the protection of individuals, associations, or corporations who divert, transport, and distribute water for that purpose.

At the same session the legislature provided for taxing the rice growers, and at the session of 1900 the rice grower of the upland prairies received protection from unlawful diversion, and the canal

owners from interference with headgates by water users, by the provisions of section 1 of act No. 24, which is as follows:

Any person or persons who shall knowingly or willfully cut, dig, break down, open, close, or dam any canal, ditch, intake, flume, or levee, the property of another, for the purpose of irrigation or drainage, with the intent to maliciously injure any person, association of persons, or corporation, for his own use or advantage, unlawfully and without permission, with intent of stealing, taking, or causing water to run or pour out of such canal, ditch, flume, or levee and applying the same to his own or others' advantage or to the injury of others, or by constructing a dam or other obstruction in a canal, ditch, or intake, so as to prevent or interfere with the use of water by others, he, she, or they so offending shall be deemed guilty of a misdemeanor, and on conviction thereof shall be fined in a sum not less than fifty nor more than five hundred dollars, or imprisoned in the parish jail not less than ten days nor more than six months, or both, at the discretion of the court.

It is not apparent that any of these statutes provide in any way for official control of the distribution of water used in irrigation.

CONDITIONS ELSEWHERE.

A comparison of the conditions which prevail in Louisiana with the conditions in some of the States where irrigation lies at the foundation of all agriculture discloses a marked similarity in the problems to be dealt with. The evolution of the water laws of the West has been slow, but after fifty years of careful study and persistent effort on the part of irrigators and canal owners, wise regulations governing the diversion and use of water have become permanently established. This has not been accomplished without a struggle. Diversion and use of water came first, and were followed by enactments to give stability and security to the interests created by this development. The ancient doctrine of riparian rights, which had been handed down from time immemorial, was abandoned, because irrigation and reclamation of land meant a diversion and use of water, while the maintenance of the ancient doctrine meant neither. In Louisiana the situation is an almost exact counterpart of that which obtained in the early days of irrigation in the West. Water is diverted from streams, and land which before irrigation was almost without value is being made productive and profitable beyond the expectations of the most hopeful inhabitant of fifteen years ago.

The conditions which forced this radical change of law and policy brought about a curious change in the basis of agricultural values. In the arid regions land was abundant but unproductive, and water was scarce. The market value of the land was nominal, and remained practically stationary, unless its settlement or transfer carried also a right to water for irrigation. Thus rights to water became the actual basis of value, and this is the situation in the arid and semiarid States to-day. It is also, in a measure, the condition in the rice districts of Louisiana and Texas. The value of agricultural land on the upland

prairies of southwestern Louisiana has risen from less than $3 an acre to $40 and upward an acre, and wholly because of the availability of water for irrigation. Without irrigation the prairie lands of Louisiana would have no greater value now than they had twenty years ago. Water is the basis of their value, and the establishment and protection of rights to its use will in time be found as necessary in the rice districts as elsewhere.

Another question equally as important as the right to use water in irrigation early confronted the farmers of the arid States. The arrival of numerous settlers in the valleys of the West, where land was easily reclaimed, led to an attempt to water more land than the streams could supply, and forced an early consideration of which appropriators should be deprived of water when the supply was not sufficient for all. The early settler, who at first had an abundance of water, was disturbed by the spectacle of a rapidly diminishing supply. Overappropriation, which at first was the exception, soon became the rule, for land was more plentiful than water to irrigate it. Some solution of this question of respective rights was needed, and experience gradually brought about a recognition of the justice and wisdom of giving to the first lawful appropriator of water the first right to its use. This action solved a vexatious problem, and the solution reached is believed to be worthy of consideration by irrigators along the Gulf.

The way seems to be open in Louisiana to deal with water rights as a new issue. An examination of the parish records shows no claims to water, nor did the court records reveal any adjudications. It seems reasonable that the questions which had to be dealt with by irrigators elsewhere will need to be met and solved in Louisiana. If the teachings of experience have any lesson, it is in the need of an early establishment of water titles wherever irrigation is practiced.

WATER DISTRIBUTION.

The method employed in the rice district to distribute water from the large canals has proven fairly satisfactory. Along the Bayou Plaquemine a superintendent of distribution is employed by each large plant and the duties of this officer are defined by his employers. The superintendent has personal supervision and ostensible control of all of the headgates through which water is drawn from the main canal. Under his direct command are a number of assistants, usually one for every 2,500 or 3,000 acres irrigated. These assistants walk the levees and keep them intact. Weak places are watched closely and breaks promptly repaired. The assistants also keep a watchful eye upon the growing rice and especially upon the fall of the water in the fields and report when, in their judgment, additional water is needed. When such a call for water is made the superintendent, by order or in person, opens the proper headgate and allows sufficient water to flow out and

then closes the gate. His assistant attends to the distribution of the water, seeing that the cuts are properly covered and that the supply furnished is economically used. This is the system of water distribution both in Louisiana and Texas, and during favorable seasons, it must be admitted, has worked with a fair degree of satisfaction. The fact that water is not sold for cash anywhere in the rice district, but is furnished for one-fifth of the crop, whatever that crop may be, greatly encourages cooperation between the parties interested. The companies which supply water have almost as great an interest in securing as large a crop as possible from every acre of land irrigated as the tenant who owns neither land nor water, but depends for his living wholly upon the crop he raises.

Prior to the year 1900, when the State legislature passed the law heretofore quoted prohibiting, under severe penalties, interference with headgates or canals by any person without authority from the owners to do so, some of the glaring defects of the system were brought into prominent notice. A dry season prevailed, and the superintendent had more orders for water than he could fill. The tenants, being more or less dependent upon the growing crop for support and fearful of injury to their rice, in person demanded the immediate opening of their headgates. Nothing will stampede a rice farmer more quickly or more completely than the evident change of the rich green of his rice field for the sickly yellowish hue due to lack of water. Personal interest is paramount to all other interests. It is no concern of his if the fields of other irrigators under the same canal are suffering more than his. If there is water going by his fields he is going to have it in accordance with his own judgment of his necessities, and he helps himself.

Examples of this "help yourself" practice occurred along one of the large canals near Crowley during one of the recent dry seasons. The scarcity of water alarmed the farmers, who feared for the safety of their crops. The season for maturing the rice had almost arrived, and water, in their judgment, was imperative. Away at the farther end of the canal were many rice farms in a serious condition because of the scarcity of water. There was no question but that immediate irrigation was needed to make a crop in that locality, and the superintendent was making every effort to get the water where it was needed most. He failed because the gates behind him were opened in his absence and in disregard of his orders, and the water in the canal drained off to fields not in actual need.

It is of interest to know that this high-handed, even if lawful, proceeding of the farmers was regretted by them afterwards, for, in their greed, they had filled their fields to the crowns of the levees and, a heavy rain coming up, many of the levees were washed out, and both the stolen and natural flood drained away, doing much irreparable damage to the crop

The chief defect in the prevailing system of distributing water from the rice canals of Louisiana and Texas is the failure to properly consider the interests of the lessee of water. Because of this defect, abuses which are now rare are certain to grow until a demand for a more equitable administration is complied with. The Louisiana law of 1900 makes the canal owner sole arbiter of the questions of time when the water shall be used and of the amount needed by the tenant. If the tenant were wholly disinterested in the question of labor and expense incident to the raising of his crop of rice, the law would be to him a matter of indifference. But he has a great pecuniary interest in the crop. His investment embraces mules or oxen and farm machinery; he has worked many weeks in the field, and if his farm is large, as many of them are, he has expended much money for labor. He has, in fact, a greater pecuniary investment in his crops than the owner of the canal upon which he is dependent. The owner asks but one-fifth of the crop for the water he supplies. The farmer, if he owns the land, gets four-fifths. No system of irrigation ever attempted offers better opportunity for agreement, and consequent successful administration, than this in the rice fields, since the interest to secure the largest possible yield from every acre irrigated, as between the water company and the tenant, is mutual, because of the prevailing method of paying for water with a share of the crop raised.

Although a greater area might be served with the present water supply under better methods of distribution, this way of increasing the duty of water soon reaches its limit. In the arid and semiarid States cultivation is carried on during the growing season and has a very important influence both upon the volume of water needed and upon the quality and quantity of the crops produced. Rice, however, is not a cultivated crop. The fields must be flooded for a period averaging about seventy days, and the function of the water used is not merely to moisten the soil but to keep the roots of the plant standing and growing in a medium completely saturated during that period. For this reason the possibilities of increasing the duty of water used in rice flooding are not as great as in those industries in which an occasional moistening of the soil supplies the needs of the growing crop; but that the duty of water used can be extended no one familiar with the business and methods employed is prepared to deny.

IRRIGATION FROM TAYLORS BAYOU, TEX., IN 1901.

The rice growers along Taylors Bayou, Jefferson County, Tex., were seriously affected by the drought of 1901. The extraordinary season was particularly severe upon some of the rice growers whose water supply for five or six years past had been sufficient to mature good, average crops. The Port Arthur Canal, during dry seasons, undoubtedly hastens the time when salt water invades the bayou by rapidly draining off its fresh supply and emptying it into the Sabine Pass

outlet near the Gulf. Formerly this fresh water was turned into Sabine Lake and was held back by tide water, and when the current of the bayou set backward, by virtue of the pull of the rice pumps, fresh water was assured until the close of the flooding season. This condition no longer obtains during a dry season. In view of the statement of the rice growers along Taylors Bayou, that prior to the year 1901 they had always had sufficient water for the irrigation of their crops, it is quite natural to conclude that the Port Arthur Canal is wholly responsible for the condition which prevailed this year. But the rice growers are evidently dependent in some measure upon the rainfall of the flooding season, and when this fails, as it did the present year, considerable loss is bound to result.

Taylors Bayou is a small stream with a comparatively large number of rice farms along its banks. Its only tributary of any importance is Hillibrand Bayou, and the appropriators along this bayou, while but four or five in number, are numerous enough to exhaust its supply and draw on the main stream early in the season. The main stream rises about 18 miles southwest of Beaumont, Tex., and flows in an easterly direction about 25 miles before reaching Sabine Lake, into which it empties about 2 miles below Port Arthur. The mouth of the bayou is about 10 miles from the Gulf of Mexico, and the stream throughout its entire length lies approximately parallel to the Gulf coast and distant therefrom a little less than 12 miles. It is therefore closer to salt water than the great majority of streams utilized for the irrigation of rice. Without exception, it is believed the farmers this year were compelled to abandon a considerable acreage of rice in the field. Many of them had rice too young to stand the salt-water treatment. Fields were found in which the plants stood 10 to 15 inches high, blackened and dead at the time harvesting was being carried on in fields adjacent or not far distant. A great many of the fields irrigated with salt water did not mature enough rice to pay the cost of harvesting.

The officials of the Jefferson County Canal Company state that their crop failure this year was not due so much to the dry season and early advent of salt water in Taylors Bayou as it was to their failure to complete a reservoir and canal system therefrom early enough to begin irrigation when the season first opened. The Jefferson County Canal is the largest enterprise and the lowest or next lowest on the bayou. With the reservoir completed the company expects to be free from the evils of extreme drought and salt water.

The Lovell Canal, just above the Jefferson County Canal, also draws a part of its supply from a large reservoir, but the excessively dry season was responsible for the failure to store in this reservoir sufficient water to meet the demands upon it.

Bingham Brothers, who farm their own land and also lease the canal and farm of John Ward, next above the Lovell Canal, have added a deep well to their supply of water, and thereby insured a partial crop

at least. They planted 400 acres on their own land, and estimated their crop at about 3,500 sacks, the same as they got last year. On the Ward farm they planted 800 acres, but did not expect to harvest therefrom more than 3,000 sacks. They estimated their loss, due to salt water on the Ward farm, at 2,000 sacks.

Next above the Bingham Canal is the plant of J. H. Hoopes, one of the earliest established on the bayou. Seven hundred and fifty acres were planted this year, but on June 18 pumping was stopped because of the salt water. One hundred and fifty acres were killed by salt water the last four days of flooding, and on 200 acres additional no crop was matured. Mr. Hoopes estimated his loss at 3,000 sacks of rice.

Calvin Garland, next above the Hoopes Canal, planted 800 acres this year, but was compelled to stop pumping June 5. Mr. Garland cut much that would not pay the cost of cutting. He thought his farm this year would average 4 bags per acre, as opposed to 10 bags per acre raised last year. His loss was about 4,800 bags.

J. W. Denny, above and adjoining the Garland farm, planted 375 acres and cut less than 50 acres. He did not expect more than an average of 3 bags per acre. His loss is about 1,600 bags.

George Gill, above the Denny Canal, planted 1,700 acres in 1901 and harvested less than half that much. He expected to realize 3 bags per acre. Basing an estimate of his crop shortage upon the yield last year, Mr. Gill's loss this year is close to 8,000 bags.

While some of the planters along Taylors Bayou place their yield during an average year at 10 barrels per acre, the majority do not raise so much, 9 barrels being about an average yield. Basing a judgment of the shortage upon the estimates of the farmers, the crop will not reach 40 per cent of what a fair year brings. This loss is too large to make the business attractive to capital, and it appears that some of the greatest losers are those who first established irrigation plants along the bayou. It is certain that the stream is inadequate to the demand made upon it, and for this reason some of the farmers draw a part of their supply from reservoirs which collect surface water, and others are constructing such reservoirs for the purpose. In other words, Taylors Bayou, one of the first, if not the first, in fact, of the streams to be used for the irrigation of rice, has reached the stage when an equitable division of the available supply is of vital interest to the farmers along its banks. What is an equitable division of the supply and upon what basis shall such a division be made?

The discussion of the subject of prior rights of appropriators and the law of priority which obtains in many States of the Northwest, already had in the study of irrigation along Bayou Plaquemine, need not be repeated. It is sufficient to state that the condition which prevails along Taylors Bayou in Texas does not materially differ from that which prevails along Bayou Plaquemine in Louisiana. During a

dry season both are inadequate to supply the rice fields depending upon them. In such years the supply of water should not be so finely divided that there is universal failure to raise as much as a third of a crop and the total return is scarcely sufficient to meet the cost of harvesting. The maintenance of such a situation means that sooner or later all must go out of business. Wise public policy would suggest the raising of a successful and paying crop on a reduced acreage when the water supply is insufficient for a greater area. The lawmakers of Texas, as is shown by recent legislation, have had this subject under serious consideration.

IRRIGATION LAWS OF TEXAS.

Title LX, chapter 1, act of February 10, 1852, under the heading "Regulating the mode of irrigation," provides that the commissioners' courts of each county "are authorized to order, regulate, and control the time, mode, and manner of erecting, repairing, cleaning, guarding, and protecting the dams, ditches, roads, and bridges belonging to any irrigation farms and property," etc., provided the same are owned conjointly by two or more persons and are situated outside of a corporation having jurisdiction thereof. This law also gives the commissioners' courts absolute authority in almost all matters affecting the organization, regulation, and control of such irrigation farms and properties, including election of officers; regulates rights of way, stoppage, and passage of the water, and times of use and methods of use; compels labor on necessary improvements; re-leases lots not properly farmed; permits and licenses owners of lands and water to dam, ditch, flume, and irrigate their lands; condemns property necessary for dams or ditches and fixes the amount of damage sustained, as well as decrees the discontinuance of all works injurious to the public health. While this law remains a statute of Texas, no use has been made of its provisions by irrigators of rice.

Chapter 2 of Title LX of the Revised Statutes of 1895, is an important advance in the direction of establishing irrigation in Texas upon a firm foundation. The following is an abstract of this law:

Art. 3115. All unappropriated waters of the State, ordinary flow, underflow, storm, and rainfall, where the rainfall is irregular or insufficient for agricultural purposes, are declared to be the property of the public, and may be acquired by appropriation for the purpose of irrigation.

Art. 3116. The storm or rain waters may be held or stored for beneficial purposes and diverted for irrigation, mining, milling, waterworks, and stock raising.

Art. 3117. The ordinary flow or underflow of any stream may be diverted from its natural channel for irrigation, etc., provided that damage to a riparian owner may be determined by condemnation proceedings.

Art. 3118. Appropriation of water is confined to objects enumerated in art. 3116.

Art. 3119. Priority of rights is determined by date of appropriation.

ARTS. 3120, 3121. An appropriator, within 90 days after beginning construction of irrigation works, must file and record in the office of county clerk a sworn statement of location of headgate, name of canal, size of canal in width and depth, carrying capacity in cubic feet per second, name of stream from which taken, time when work was commenced, name of owner, and map showing route of canal. In case the water is taken from a reservoir, dam, or lake, the statement filed shall include the locality, name of survey upon which located, acreage covered, boundaries of reservoir or lake, and area of watershed from which collected. With the filing of such statement, claimant's right relates back to time when construction began. Owners of works constructed prior to the passage of this act shall file and record like statements within 90 days after the law goes into effect, but a failure to do so will not work a forfeiture of such rights nor prevent their establishment in the courts.

ART. 3122. Rights to water for purposes stated in art. 3116 may be acquired by filing and recording a sworn statement of declaration of intention with full description of proposed works; construction must begin within 90 days after filing said statement, and the work thereon must be prosecuted diligently and continuously to completion.

ART. 3123. "Completion" is defined as carrying water in main canal to place of intended use.

ART. 3124. Having acquired the right to divert water from a stream no appropriator shall be deprived of the use of said water or any part of it, except that riparian owners may use said water for domestic purposes; and any person whose land may be located within the watershed from which the storm waters are collected may construct dams upon his own land to store water for domestic purposes; but all excess of water above that lawfully appropriated may be appropriated by others.

ART. 3125. Corporations may be formed and chartered for the purpose of constructing and operating works for the diversion of water and shall have power to sell water rights secured by liens on land or otherwise, or otherwise dispose of the water under their control. All persons owning a possessory right to the use of water in a canal or other works shall be entitled to be supplied therefrom in accordance with contract terms; but if the price is not agreed upon the owners of the water, having more than sufficient to meet existing contract requirements, must nevertheless deliver water to such persons at such prices as may be reasonable and just; and in case of drought or accident, causing shortage in the supply, all consumers shall be provided pro rata, according to the amount to which each consumer is entitled. A permanent water right shall be an easement to the land and pass with the title thereof. Any instrument of writing providing a permanent water right may be recorded the same as land transfers.

ART. 3126. Rights of way, 100 feet wide, over all public, public free school, university, and asylum lands, and the use of the material thereon for construction purposes, is granted to corporations and associations, and right of way over private lands and land for storage reservoirs may be obtained by contract or by condemnation proceedings. Water belonging to riparian owners may be obtained by condemnation and payment of damages to private property as provided in railroad cases, and the delay thus caused shall not work a prejudice to the person constructing the canal or other works.

ART. 3127. Surplus water shall be returned to the stream from which taken.

ART. 3128. Right of way along or across public highways is granted, but necessary bridges must be constructed and the usefulness of the highway in no way impaired. The route of a public highway over a dam site, reservoir, or lake may be changed by the commissioners' court at the expense of the persons owning said site.

ART. 3129. No cause of action for damages by live stock shall accrue to owners of canals, etc., unless the same shall be kept securely fenced.

ART. 3130. A superior preference lien upon all the crops raised upon irrigated land

is granted to persons owning the irrigation works which supply the water thereto under lease or contract.

Art. 3131. Corporations organized under general laws are empowered to acquire lands for irrigation by donation or purchase or in payment of stock or water rights, to hold or transfer the same or borrow money thereon for construction, maintenance, and operation of necessary irrigation works, and may issue bonds and mortgage its property to secure the payment of debts, but no stock or bonds shall be issued except for money paid, labor done, or property actually received. All fictitious increase of stock or indebtedness shall be void. All lands acquired except those used for the construction and maintenance of irrigation works shall be alienated within 15 years from the date of their acquirement or be subject to judicial forfeiture.

PENAL LAWS RELATING TO IRRIGATION.

Title XIII, Penal Code.—Offenses against Public Property.

Art. 482. Any person who shall knowingly or willfully destroy, injure, or misplace any bridge, culvert, drain, sewer, ditch * * * shall be guilty of a misdemeanor, and upon conviction thereof punished by a fine of not more than five hundred dollars, and shall be liable to the county and any person injured for all damages caused thereby.

Art. 495. If any person amenable to the laws governing irrigation shall fail or refuse to work on any ditch or aqueduct when summoned so to do by the proper authority, he shall be fined not less than one nor more than five dollars.

Art. 496. Any person who shall willfully or through gross negligence injure any irrigating canal or its appurtenances, wells, or reservoirs, or who shall waste the water thereof, or shall take the water therefrom without authority, shall be deemed guilty of a misdemeanor, and for each offense shall be liable to a fine not exceeding five hundred dollars.

Title XIV, Chapter III.—Offenses against Property.

Art. 803a. Any person who shall willfully or through gross negligence injure any irrigating canal or its appurtenances, wells, dams, or reservoirs, or who shall waste the water thereof, or shall take the water therefrom without authority, shall be deemed guilty of a misdemeanor, and for each offense shall be liable to a fine not exceeding five hundred dollars.

Art. 803b. Any person who shall willfully or maliciously injure or destroy any irrigation canal or its appurtenances, or any irrigation reservoir, dam, well, or any of the appurtenances thereto to the extent of fifty dollars, or if said injury shall amount in value to fifty dollars, shall be deemed guilty of a felony, and for each offense shall be punished by confinement in the State penitentiary for not less than two nor more than ten years.

The principles of State ownership of the unappropriated waters of the State and of the priority rights of appropriators are defined and established by this law, and the requirements that the appropriator from a stream shall make a matter of record the location of his head-gate, the name of the owner of the canal, and the number of acres irrigated, as well as a statement of the purpose of the appropriation, conforms, in a measure, to enlightened legislation elsewhere. But the law can be improved in the following particulars. Instead of the filing of statements of appropriation, which are now prepared without

authoritative supervision, as provided by article 3120, permits to appropriate water based upon a knowledge of the local conditions, including the water supply available for diversion, should be required, and the applications for water, together with the permits and a final record of completed appropriations, should be kept by an officer of the State, as well as by the county clerks.

The size of the canal and its carrying capacity are unimportant particulars, but the amount of water used is important. The State fails to designate the volume of water to which an appropriator is entitled for the irrigation of a stated area of land. The first or second or any other early appropriator might claim and record title to five times as much water as he needed to grow and mature his crop. Experience shows that usually he will claim all that the law will allow, regardless of what his necessities may be. It is manifest that if no limit to the amount claimed for each acre to be irrigated is established by law a proper and equitable division of any stream would be impossible. The relation between the volume claimed and the area irrigated must be determined before any just division can be made.

Should an appropriator having a headgate upon a stream whose flow is inadequate to meet the demands upon it go into court and obtain a decree of priority, he would still be far from obtaining the object of his suit, for the law makes no provision for cutting off the later appropriators. The appointment of a commissioner by the court for the purpose of enforcing its decrees has resulted in a lack of uniformity, and the method is cumbersome and unsatisfactory as well as expensive to the irrigators. Appeals to a court will be made only during times of water scarcity, and at such times, of all times, is needed careful administration of water laws by an officer fitted through training and experience to divide water intelligently and properly carry decrees into effect. Intelligent and authoritative administration of irrigation law is as necessary as law itself.

USE OF PUMPS IN RICE IRRIGATION.

All the water used in the irrigation of rice upon the upland prairies of southwestern Louisiana and southeastern Texas has to be lifted by pumps. Two styles of suction pumps are in common use in the rice fields, the rotary and the centrifugal, the latter being the prevailing type. The rotary pumps, when properly established, show the higher degree of efficiency, but they are heavy and, being coupled directly to the engine fly-wheel shaft, will not admit of any disturbance or settling of the foundations of either pump or engine. Greater care is therefore required in selecting sites for foundations for the heavy rotary pumps, and equal care must be exercised in their construction. Where properly established, however, the rotary pumps are bound to

give satisfaction, because they are meters and deliver a certain quantity of water per revolution. There is practically no loss of power in their operation, and their degree of efficiency is high. The rotary pumps are run at a comparatively slow speed, also, which is an advantage in the matter of wear and tear on machinery. The centrifugal pumps are run at a high speed, varying between 100 and 1,800 revolutions a minute, the speed diminishing as the pumps increase in size, but increasing with the height of the lift. The popularity of the centrifugal pumps is due to their comparative lightness, ease of establishment, simplicity, and low cost. Their principal parts consist of a shell which contains a revolving runner, impeller, or piston. The water is drawn in at an opening or openings in the center, given a rapid centrifugal motion by the revolutions of the impeller, and discharged through a pipe on the periphery of the pump shell. The operation of these pumps is not affected by silt or sand in the water, their discharge is uniform, and the vibration is not excessive. The foundation necessary is comparatively simple and inexpensive, and, since the pump is invariably run by belt or rope transmission, considerable disturbance in position may occur without interfering with the operation or efficiency of the pump, the chief requirement being that connections between the discharge pipe and the flume be watched to prevent leakage and waste of water. Two styles of centrifugal pumps are used, and they are named from the position of the pump shaft. If the shaft is vertical the pump is a vertical pump; if horizontal, a horizontal pump. These pumps are established in two positions, just below the surface of the water to be pumped and at some distance above same, the distance varying between 4 and 20 feet, the average in the rice district being about 8 feet. The total lift of these pumps when raising water from a stream, bayou, or lake varies between 7 and 35 feet, 20 feet being a common total lift. In order to raise the water to the higher levels on the larger plantations two or more additional pumping stations are often required, the height of these supplemental lifts sometimes reaching 27 feet. The submerged centrifugal pumps, as observed, were invariably of the vertical pattern. The horizontal pump, with the pulley and bearings inclosed in a water-tight box or pit while the pump itself is submerged, has not been utilized, so far as learned. Such an arrangement would be inexpensive and the cost for extra valves and priming apparatus would be avoided. Submerged centrifugal pumps are generally utilized for lifts varying between 3 and 10 feet. For such lifts a cheap vertical pump without metal casing and set in a simple wooden box is being used extensively. The writer found submerged centrifugal pumps of different makes utilized for additional lifts upon many large plantations and by small farmers who irrigated rice from artesian wells. In the latter case, where the water overflowed the casing at the surface or rose to within

10 or 12 feet of the surface. excavations were made deep enough to allow of the vertical pumps being submerged.

Pumping from deep wells of comparatively small bore for the irrigation of rice is now extensively practiced in the prairie land rice districts. These wells are used singly or in batteries of 3 or 4. driven 12 to 20 feet apart. In the latter case one pump large enough to operate the entire series simultaneously is usually installed. the several wells being connected to a larger horizontal pipe which is attached to the suction pipe of the pump. Hundreds of wells have been driven in Calcasieu Parish. La., and the success attained there has encouraged the small rice growers elsewhere in the district, both in Louisiana and Texas. to bore for water for irrigation. Water in considerable abundance is found at and near Jennings, La., at depths varying between 90 and 150 feet. This water is warm. clear, and perfectly fresh and is contained in sand and gravel beds in which the mixed material becomes coarser with depth. This sand and gravel bed in many places has not been pierced, but well casing has been driven into it to a depth of 120 feet. but. on account of the fineness of the sand in the upper portions, no attempt was made to obtain water until the coarser stratum was reached. Much annoyance was caused by pumping great quantities of sand in the early stages of these experiments. The sand passed through the pumps without interference, but settled in the flumes and ditches for distributing water, and much was carried to the rice fields where it was not wanted. Annoyance was also caused by the choking up of the screen at the bottom of the well, but these difficulties have, in the main, been overcome by keeping careful records of depth and character of strata pierced, so that

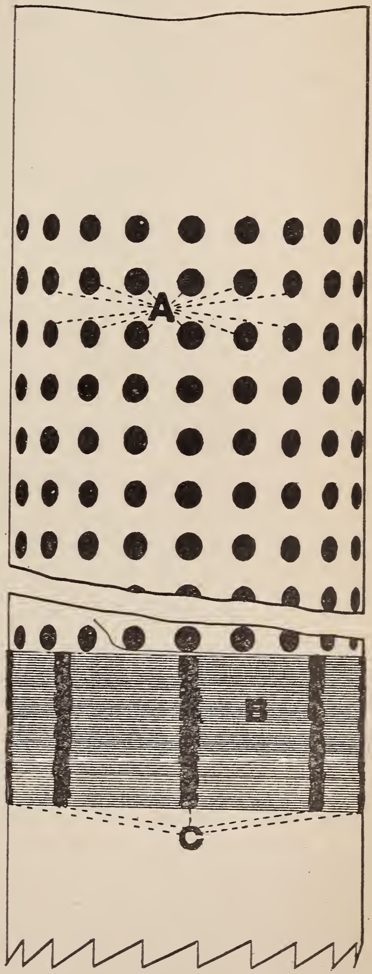


FIG. 9.—Showing method of constructing screen on artesian well casing. A, perforations in casing. B, wire wound on casing. C, lines of solder.

layers of coarse sands and gravels only are tapped by the perforated pipe and screen.

Many plans for straining the water at the bottom of the casings have been tried. The screen in the first well driven, that of Dr. Remage, of Jennings, consisted of pipe with one-fourth-inch holes bored thickly for a distance of 36 feet and the perforated portion wrapped with brass wire gauze. The perforations in this pipe were found to be too small and the wire gauze too weak to stand the suction from the pump above. In the screens now generally used perforations in the well casing are three-fourths to seven-eighths of an inch in diameter, averaging about 1½ inches between centers, and the perforated portion is carefully wound with a galvanized-iron wire. On 10-inch pipe No. 14 wire is wound 9 wires to the inch; on 18-inch pipe No. 16 wire is wound 11 wires to the inch; and on 6-inch pipe No. 17 wire is wound 14 wires to the inch (fig. 9). A common machine-shop lathe is used for winding the wire upon the casing, and the wire is not only wound on tightly, but is soldered in place to prevent its sliding, so as to close the openings between strands. Seven rows of solder are placed upon a 10-inch pipe, the number increasing with larger pipe and decreasing with smaller pipe.

PUMP FOUNDATIONS.

Foundations for irrigation pumps in the rice districts are made of brick laid in cement, of concrete, of piling with frame superstructure, and of wooden crib work. Probably simple crib work is used more than any other form of foundation for the smaller sizes of centrifugal pumps, but a foundation of piling should be provided for all large pumps, especially where the pumps must be placed over a stream, bayou, lake, or other reservoir, or in close proximity tc the banks of the same. In all cases a proposed location for a foundation should be carefully examined and the character of the soil determined before permanent works are put in. Failure in this regard has been fruitful of great loss, delay, and annoyance. Where the pumps are especially heavy deep piling should be driven first. A heavy wooden platform may then be constructed upon the piling and upon the latter a heavy cap or crown of concrete laid. Sometimes the whole may be finished in hard brick laid in cement, the best grades only being used. Safety and permanence would seem to require that all pumps lifting water 15 feet or more, in a district where there is an admixture of sand strata among the clays, should have a piling foundation. There can be no question about this in regions where quicksands abound. Foundations for engines and boilers supplying power for pumps need not be discussed at length. They are always located upon firmer ground than are the pumps, and can therefore be more easily established. However, the character of the soil, which is practically saturated with water for a considerable portion of the year, requires that care should be

exercised. Concrete and cement mortar should be used freely, and where doubt exists as to the stability of any proposed engine foundation, piling should form the base of the work.

BOILERS AND ENGINES USED.

A great variety of boilers and engines are used in the rice district. The engines are usually horizontal, and in the great majority of cases transmit power by a belt or rope drive. Any well-made and strong engine will do. Many of the engines are compound, and the larger plants often run condensers. The boilers are usually horizontal and of the common return tubular pattern.

DUTY OF CENTRIFUGAL PUMPS.

The working capacity of pumps of different sizes is a matter of great concern to the prospective investor in water-lifting machinery. It may be said generally that the pump manufacturers have made careful measurements of the discharge of their particular sizes and styles of pumps, and that, under the conditions named in their catalogues, the figures are substantially correct. But these catalogues do not furnish the planter with any information as to the amount of water needed by an acre of rice during the flooding season; in other words, they do not tell the prospective rice grower of Louisiana or Texas how large a pump he will need to grow 100 acres or 1,000 acres of rice. The following table has been prepared for the purpose of supplying this information. The centrifugal pump was selected because of its great popularity, as evidenced by its extensive use, but the use of no other style is deprecated, and of course any pumps discharging equal volumes of water will irrigate similar areas of land. The sizes of pumps selected are those in most common use, and the column of discharge shows for each size the mean of the discharges claimed by a large number of manufacturers who supply pumps for the rice district. The same may be said of the column showing power required for each foot of lift, and the column showing the quantity pumped is also an average.

Duty of centrifugal pumps for irrigation, lifting water less than 35 feet.

Diameter of discharge pipe.	Discharge per minute.[a]	Power required for each foot of lift.	Quantity pumped per day.	Area irrigated in 70 days.
Inches.	*Gallons.*	*Horsepower.*	*Acre-feet.*	*Acres.*
4	435	0.27	1.87	60
6	1,025	.56	4.53	158
8	1,900	.98	8.39	294
10	3,000	1.54	13.25	464
12	4,275	2.06	18.89	661
15	7,000	3.34	30.93	1,083
18	10,000	4.62	44.19	1,547
20	13,000	5.68	57.45	2,011
24	18,500	6.63	81.76	2,862
30	27,350	9.45	120.87	4,230
36	35,000	13.46	154.68	5,420

[a] Discharges computed for a velocity of 12 feet per second in the discharge pipe.

The last column of the table is based upon actual measurements of water and is believed to indicate the minimum of acreage which the pumps will irrigate, the maximum under favorable conditions being at least 25 per cent greater. The depth of water provided is 2 feet, and attention is called to the fact that the measurements of water made during the season of 1901, noted elsewhere (see pp. 23, 27), gave 19.66 inches at Raywood, Tex., and 16.47 inches at Crowley, La. Attention is also directed to the fact that the actual irrigation period, embracing the first and last floodings of the experimental rice farms at the places named, in neither case exceeded fifty days. This leaves a considerable margin of the stated pumping season of seventy days to offset other possible or accidental depressing influences such as increased lift caused by fall of water in the streams due to excessive drought; the running of the pumps at a slightly reduced speed, which is often found desirable; differences in climate, especially in precipitation; differences in the composition of the soils between the eastern and western limits of the district; lower temperature of the water from artesian wells, etc. The acreage as stated in the table is believed to be a perfectly safe estimate for prospective purchasers of pumps which are to be used in the irrigation of rice in southwestern Louisiana and southeastern Texas.

COST OF FUEL PER ACRE IRRIGATED.

Three kinds of fuel are used to make steam for irrigation pumps in the rice district—coal, wood, and oil. Coal is the most expensive, because of the long hauls necessary, and oil, based upon the experience of the one year which has passed since the Beaumont oil basin was discovered, is by far the cheapest and most satisfactory. Pittsburg, Kans., bituminous coal sold as high as $4.75 per ton and wood for $1.50 to $3 per cord, while the oil delivered f. o. b. in car lots cost from 48 cents to 62½ cents per barrel. Based upon reports received, the cost of fuel necessary to irrigate an acre of rice was between 60 cents and $1 when oil was used, between $2 and $3 per acre when wood was used, and fully as much for coal as for wood. Crude mineral oil has proven a most satisfactory fuel. A uniform and high pressure in the boilers is easily maintained, and one fireman can easily handle a battery of half a dozen or more large boilers. The combustion is practically complete, and no injury to the boilers from the hot blast has yet been noted.

Acknowledgment is hereby gladly made to the rice planters of Louisiana and Texas for courteous responses given to letters of inquiry relative to the pumping machinery they use, and also to the manufacturers of irrigation pumps for complete information regarding the products of their factories.

JULIUS BIEN & CO. LITH. N.Y.

THE BOAT-TAILED GRACKLE.
QUISCALUS MAJOR, VIEILL.

BIRD DEPREDATION IN THE PRAIRIE RICE FIELDS.

BLACKBIRDS.

During the writer's first visit to the rice fields of Louisiana and Texas, in February, 1901, his attention was directed to the great flocks of several species of birds which were foraging in the stubble and along the field levees of the rice farms. In the main, these flocks were composed of the common summer residents of the North, which were wintering in great abundance along the Gulf coast. Their chosen field of occupation extended back from the shore line for a distance of about 50 miles. By far the most abundant of these birds were the several species of blackbirds, the redwing (*Agelaius phœniceus*), cowbird (*Molothrus ater*), rusty grackle (*Scolecophagus carolinus*), the purple grackle (*Quiscalus quiscula*), the bronzed grackle (*Quiscalus q. æneus*), and the boat-tailed grackle (*Quiscalus major*) (Pl. XVIII), whose numerical standing in the flocks was about in the order named. No rice field, especially in Louisiana, where the February observations of the writer were made, was without its immense flocks of blackbirds. Soon after sunrise they emerged from the wooded banks of the bayous and directed their flight to the open rice fields where for some hours they foraged in the old rice stubble and also, but not numerously, in the fields newly planted for the coming crop. If there were any choice of location it seemed to be the field levees. These elevations, which cross the fields in almost every direction, were covered with uncut, fallen stalks of both white and red rice which, in places, made quite a mat of straw. Under this straw was much grain, and the blackbirds appeared to be aware of the fact. One had but to walk along these levees to see the evidences of careful search made by the birds. The holes through the straw and weedy covering, where a large flock had recently alighted, were numerous enough to indicate that all or nearly all of the unburied rice had been removed. In the open fields were seen countless thousands of these birds swarming in the stubble. They would arise in a cloud from time to time and move to some adjacent cut or field, settle again and forage industriously as before. During the middle of the day the majority returned to the woods where characteristic concerts were held. During the latter part of the afternoon the birds again went to the rice fields and shortly before sunset returned by low but rapid flight and in lines a mile or more in length to the wooded bayous to roost. The writer killed a number of these birds both during the noonday siesta and from the returning flocks of the evening. An examination of their stomachs revealed a great assortment of insect remains and a commendable collection of the grains of all the varieties of rice found in the rice fields. The long-grained Honduras, the

shorter and thicker Japan, and the characteristic red rice were undoubtedly present. The forms and sizes of the grains led to a definite conclusion as to their identity. All were greatly discolored from many months contact with the wet earth, but the smallest grain was by far the darkest in color, being, in fact, uniformly jet black. In the stomachs of some birds the small, black grains were found to be most numerous, in others the lighter grains.

It would be difficult to form even an approximate estimate of the amount of rice removed from the fields during the time between November 1 and April 1 by the winter resident blackbirds. The stomachs examined contained from three to twelve grains each. It is very doubtful if this represented a fair average of their day's work, but assuming that it did, the quantity of dangerous seed removed is enormous. There are one hundred and fifty days in the period named, and the blackbirds that winter in the rice fields number millions. The evidence obtained warrants the conclusion that these birds remove from the rice fields enormous quantities of rice, which if left to sprout, would insure the spread of red rice and a certain consequent reduction in the value of the annual crop.

The writer had heard it said that the blackbirds would not eat red rice, but the evidence offered in the dissections was conclusive that they do. In every instance the husk, or hull, of the grain found in the stomachs had been removed before it was swallowed, and the fact that a grain was small and black as jet had not interfered with its appropriation as food.

With the approach of the planting season the strange instinct of migration seizes 95 per cent of the blackbirds, and little is seen of most of the species until harvest and the returning migrants arrive. The boat-tailed grackle, the giant of the flocks, however, remains and the number is augmented by fresh arrivals until some hundreds are at times seen together. In May they are quite common in Texas and the same in Louisiana in the latter part of June. During the writer's visit in May they were rearing their young, and the males, in small flocks of 8 to 20 birds, were usually found wading in the sloughs, shallow pond margins, and wet rice fields in search of that insect, crustacean, and other life which forms the bulk of their food. During the months of September and October the boat-tailed grackle was found in flocks aggregating several hundred birds. They were foraging in the rice fields, and their diet was about 50 per cent rice. But a small percentage of the rice eaten came from the shocked grain and little or none from grain standing in the field. The birds preferred the fields of wet stubble into which they would drop and, from a distance of 50 yards, totally disappear. Whether they foraged upon the ground because of their natural preference for wet localities or because they wanted grain softened by the water and mud is a matter

for conjecture, but that they fed mostly upon the ground was determined by careful observation. The boat-tailed grackle is not sufficiently abundant to menace the rice fields even were his palate chiefly satisfied by this cereal. The writer does not consider them injurious, but on the whole decidedly beneficial. One locality, however, was found where the blackbirds during the past six years had proved a nuisance. This was on one of the lower plantations along Hillibrand Bayou, about 10 miles south of Beaumont, Tex. Mr. J. Viterbo informed the writer that he had been compelled to employ regularly five or six gunners in the fields to drive away the birds, and that they were only partially successful. In 1900 he lost over 60 acres of rice from blackbird depredations, but the present year, 1901, the birds were not so troublesome as in the past years. Last year his rice was badly lodged and had to be cut with a mowing machine instead of a reaper and binder, and the sheaves were loosely made. This made a loosely constructed, open shock into which the birds penetrated. Mr. Viterbo said, further, that the birds appeared in flocks about the middle of July and were a menace from that time until the harvest was over. These depredations were committed by summer residents, the months of July and August, when their activity was the greatest, being too early for the arrival of the migrating birds from the North. The farms raided lie closer to the sea-marsh district than any that were visited and probably are in close proximity to extensive breeding grounds. The rice farms 6 to 10 miles southwest and up Taylors Bayou have never been menaced by birds of any kind.

THE MEADOW LARK.

The birds next in abundance to the blackbirds are the meadow larks (*Sturnella magna*). It could hardly be said that these birds are gregarious, although from five to eight or ten birds were often found feeding together during the months of February and March. The well-known habits of this friend of the farmer were not modified in its winter home in the South. The larks frequented the rice stubble, especially the borders of the fields, and were often found along the high levees of the larger canals where there was favorable opportunity for finding their favorite insect food. The birds were common everywhere, but not abundant enough to excite comment. In May and June there appeared to be no appreciable diminution of their numbers, nor did the writer note anything in their habits which would excite the suspicion that they were taking more rice that was sown broadcast than the interest of the farmer would allow. It is a fact that the larks were never seen picking up the grains of rice although they may do so to a limited extent when their normal soft-bodied insect food is scarce. They appear to prefer the grass and prairie lands to the growing rice fields.

Mr. C. H. Bering, of Houston, Tex., who planted a small field of rice about 8 miles west of that city in 1900, said the larks robbed him of much rice seed which was sown broadcast and not well covered up. Mr. Bering planted late and, through inability to get his pumping plant in working order, the seed lay upon the ground in all stages of germination and early growth. The season was a wet one, and the rice in the condition the birds found it must have been extremely palatable. At any rate, said Mr. Bering, they arrived every morning in small flocks and helped themselves generously to the uncommon fare displayed so temptingly to the eye. If the rice had been planted as it should have been, that is, sowed and carefully harrowed in, or, better yet, drilled, the meadow larks would not have known of its existence. Mr. Bering admitted this in conversation upon the subject. This is the only case that was noticed where the larks damaged a rice grower. The stomachs of the birds killed in winter showed that a very small quantity of rice was taken as food. The winters are so mild along the Gulf coast that these insectivorous birds have no difficulty in finding their normal food. The striking exception to their general habits in the later spring, noted above, should not in any degree prejudice the rice grower against them.

THE MOURNING DOVE.

This bird, called the turtle dove in the South, as elsewhere in the United States, was found quite common upon the prairie rice fields of Louisiana and Texas. The mourning dove (*Zenaidura macroura*) winters along the Gulf coast, or is a resident there, in considerable numbers. In February and March they usually were found in small flocks of 5 to 15 birds. During the early forenoon hours many of these flocks could be seen hurrying in rapid and characteristic flight to the fields where rice still lay untouched upon the surface of the ground. Their method of foraging was similar to that of the blackbirds, although of course there was no comparison as to numbers. But the mourning doves were plentiful enough, considering their almost strictly granivorous diet, to be of benefit to the rice grower. Like the blackbird, they should receive adequate protection and be encouraged to winter in the rice stubble.

THE RICEBIRD.

Of the smaller birds which have a predilection for rice as a diet, or which are accredited with habits injurious to the interest of the rice grower, the ricebird, or reedbird, or bobolink, of the North (*Dolichonyx oryzivorus*) is the greatest bane of the Carolina planter. But careful search failed to reveal a single individual in either Louisiana or Texas. This district is so far west of the regular route traveled by the ricebirds in their migration that their presence, if it ever occurs,

may be characterized as accidental or casual. On inquiry it was found that the birds were little known. A few planters stated that they had seen ricebirds in their fields, but it is believed that the birds they saw were the exotic house sparrow, which, from a distance and to the untrained eye, looks very much like a ricebird.

THE ENGLISH SPARROW.

About four years ago the European house sparrow appeared along the Gulf coast in sufficient numbers to excite comment. It is probable that the cultivation of rice and the continuous supply of this very attractive article of diet has had much to do with the rapid increase of this bird in these districts. By the middle of September they can be found in flocks busily foraging in the rice fields before the grain is ready for the reaper. The rice stalks are strong enough to support these little birds, which swoop down upon a field and alight upon the heads of grain, where a sharp eye was necessary to discover their presence. The climate of Louisiana and Texas seems well adapted to the propagation of this unmitigated nuisance, and their rapid multiplication constitutes the only real threat to the rice industry offered by birds in this district.

THE WILD DUCKS.

Practically every species of wild duck common east of the Rocky Mountains may be found wintering along the north and west Gulf coasts in large numbers. So abundant are these birds in some of the later harvested rice fields that the planters are forced to take special precautions against them or suffer loss. In the fall of 1900 a tenant of the Raywood Company at Raywood, Tex., named Hotz, living about 3 miles from the railroad, harvested a late crop of rice. After the rice was cut, instead of stacking it as soon as the straw in the shocks was sufficiently dry, he let it stand in the field for several weeks. Countless thousands of ducks and geese visited this rice field nightly and ate enormous quantities of the grain. Not until long after dark did they begin to arrive from the bayous and marshes and salt-water inlets, where they rested during the day. None of the water fowl feed in the rice fields during the day, but, instead, feed at night when they can do so in comparative safety. As soon as it began to get gray in the East the birds arose from Mr. Hotz's field and soon disappeared. He stated that he lost half his crop before he could get a thrashing machine to save it. Other farmers in his neighborhood lost smaller portions of their rice crop in the same way. Those farmers who took the trouble to stack their rice as soon as it was sufficiently cured in the shock lost but little from the depredations of the ducks and geese; too little, in fact, to make the event worth recording. It takes but little more time and labor to stack the grain than it does

to haul it in wagons to the thrasher. Indeed, considering the necessity for hiring more help to keep the thrasher running when the grain is hauled from the field, the small farmer would doubtless save money by stacking as early as possible when he could take his time and do it himself. At any rate, a well-made stack of rice with the heads turned in is safe from the ducks and geese.

The water fowl are early migrants and are not found in the rice fields to any extent during the planting season, but all winter long they feed upon the rice which has lain in the fields since harvest time. In this way they are undoubtedly of the greatest benefit to the rice grower. But the demand for them for the table is so great that the boom of the shotgun is heard in the rice fields all night long and all winter long. The birds early become too shy to feed by daylight and are shot on the wing during moonlight and starlight nights. Those which are only crippled and fall at considerable distances from the gunner are picked up by the turkey buzzards and black vultures, which industriously and thoroughly work the fields during the early forenoon.

Observant rice growers who have watched the wild fowl and measured the extent of their depredations fully agree that good rice farming, which includes intelligent handling of the crop after the reaper has left the field, will place these birds wholly in the beneficial list. There is little danger to rice stacks and the cleaner the fields are gleaned of fallen grain after harvest the better. The ducks are the most effective of the feathered gleaners in the rice field after the harvest is over.

LITTLE BLUE HERON.

But one other of the larger species of birds was noticeably common in the rice fields. This was the little blue heron (*Ardea cærulea*, Pl. XIX) which was found alone or in small flocks of 5 to 8 birds scattered over the fields of rice stubble in February, March, May, and June, wherever standing water was found. During the early months the typical blue form appeared by far the most common, but during May and June pied and pure white individuals were more common than the blue. Birds nearly white but with a few blue wing quills were the commonest form at this season. In southeastern Texas these birds are called "levee walkers" by the rice planters on account of their habit of alighting upon the levees which project from a few inches to two or three feet above the floods of the field or the water in the canals. Along these elevations they stalk, occasionally making excursions into the shallow water in search of their common food, small fish, reptiles, crustaceans, and insects. The rice planters say they are great foragers of the crawfish, which often does much damage by boring through levees and starting the leak which, unobserved,

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LITTLE BLUE HERON.
ARDEA CÆRULEA, LINN.

soon causes a washout and much destruction of property. On this account the birds were seldom molested by hunters, who do not hesitate to shoot birds of every other species. It was surprising to find this little and handsome heron so common, and it is certain that the rice grower will continue to throw over it that kindly protection and extend that good will, which the bird will undoubtedly return in service performed many fold.

This concludes the list of birds which frequent the prairie rice fields of Louisiana and Texas in numbers sufficiently great to cause inquiry to be made as to the effect which their presence is likely to have upon the production of the staple cereal. Observation extends only over the season of 1901, beginning February 15 and closing October 15, but it is believed the conclusions reached are fully justified by prevailing conditions. At the present time no species of native bird need be feared in the district as a whole. A few isolated localities, such as that along the lower reaches of Hillibrand Bayou, where local conditions are especially favorable for the multiplication of blackbirds, may suffer, but the rice district as a whole, which now extends from Vermilion River, Louisiana, on the east, to the Colorado River, Texas, on the west, has nothing to fear. The presence of the European house sparrow, commonly known as the English sparrow (*Passer domesticus*), in considerable flocks constitutes what might be called the only threat against the rice industry offered by birds. However, it is yet too early to arrive at a definite conclusion as to this sparrow, the Gulf coast having been occupied by the bird but a few years.

IRRIGATION OF RICE IN NORTH CAROLINA, SOUTH CAROLINA, AND GEORGIA.

By George H. Keeney,
Special Agent, Irrigation Investigations.

In the year 1694 a Spanish vessel, being storm-bound, put into port at Charleston Harbor. The ship, beaten by the storm and in need of repairs, was compelled to lay in harbor for some time. It was while here that her captain gave to one of the citizens of Charleston, Thomas Smith, a handful of rough rice. Smith took the grain and planted it in his garden. The plant thrived and bore abundantly. Smith then gave seeds of the plant to his neighbors. They planted it and were successful in raising crops. The planting continued and the colonists cultivated the grain with great care, till at length from that single handful of rough rice was developed the famous Carolina rice, now known the world over.

THE RICE-GROWING SECTION.

Rice is grown in the Gulf and South Atlantic States, in some of which it is the chief cereal product. The land used for rice culture in the Carolinas and Georgia is generally low and marshy and usually borders on rivers emptying into the ocean. This furnishes, within a certain limit, a high and low tide of fresh water. The tide from the ocean ascends the rivers, causing them to rise. The fields are flooded. With the ebbing tide the river recedes and the fields are drained.

To-day Louisiana furnishes more than one-half of the rice raised in this country, but for a century after rice was introduced Georgia and the Carolinas furnished the principal part. For fifteen years preceding the civil war these States produced 105,000,000 pounds of cleaned rice each year. Since then, changed labor conditions and losses incurred by storms have prevented the rehabilitation of many plantations. From the close of the war to the year 1881 the annual yield of these States was a little more than 40,700,000 pounds. Since 1881 the annual yield has been in cleaned grain about 45,700,000 pounds.

The section dealt with in this report lies between the Cape Fear River in North Carolina and the Satilla River in Georgia. (Pl. XX.) The total area cultivated is about 45,000 acres. The total area that could be cultivated is about 80,000 acres. In other words, there are about 80,000 acres of rice lands in these States, of which little more than half is cultivated.

SOURCES OF WATER SUPPLY.

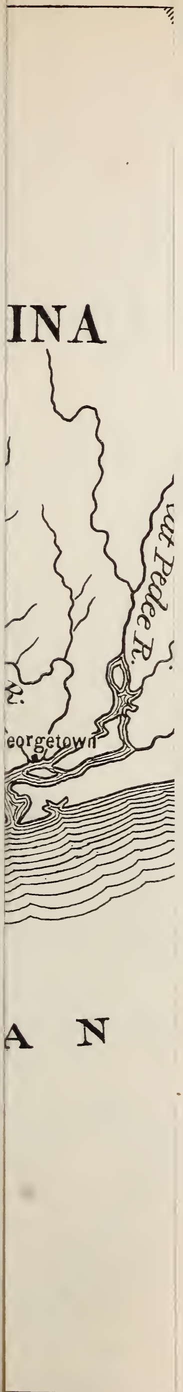
Most of the water used in this section is supplied from the following rivers and their tributaries: Savannah, Combahee, Ashepoo, Edisto, Cooper, Santee, Sampit, Black, Pedee, Waccamaw, Cape Fear, and Satilla. Some of these streams carry a sediment that greatly enriches the soils they flood. The Savannah, Santee, Pedee, and Cape Fear rivers take their source in the Blue Ridge Mountains. On account of their length and the territory that they drain they are subject to sudden and heavy freshets. When one occurs and the waters are met with high tides propelled by a heavy storm at sea great damage is wrought to rice lands, washing away banks and destroying growing crops. The Edisto, Combahee, and other streams do not have their source in the mountains and are not subject to these freshets, yet they are of sufficient length to carry enough water to supply all demands made upon them. The Ashepoo is sometimes short of fresh water, and to obviate this shortage some of the plantations along it are provided with reservoirs built on the smaller streams.

The Edisto and Combahee are the most satisfactory streams in the territory. Their sources are in the south central part of the State. They are seldom troubled with high water driven in by storms from the sea, yet in 1893 the rice sections on both streams were covered, causing much damage and the loss of many lives. On these rivers are situated some of the best and most highly improved plantations in the Carolina rice district.

Rice is seldom cultivated less than 15 nor more than 30 miles from the sea, following the meanders of the river. The limits of this 15-mile wide belt are determined on the sea side by the presence of salt water in the river and on the inland side by the point at which there is no longer a sufficient tide for irrigating and draining the rice lands. A 2-foot tide is taken as a minimum for this drainage and irrigation, which is, however, too little for practical purposes.

On streams near the sea where the water is too brackish to be used, and on lands above tide water, the planter must depend on some other source. To irrigate such lands water is taken from inland lakes and reservoirs.

Reservoirs are very simple in construction. A bank of earth or dam is built across a marsh traversed by a stream and included between surfaces slightly elevated. The dam of one of the reservoirs visited was from 4 to 8 feet higher than the general surface. Others are about 9 feet high, 12 feet wide on top, and 30 feet wide on the bottom, with the top finished in such a way as to make a driveway. The area behind the dam is utilized for the reservoir, and the land below the dam is converted into rice fields by the construction of banks, drains, and ditches similar to those under tide water. One of the dams


INA
Pedee R.
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NORTH CAROLINA
SOUTH CAROLINA
GEORGIA
FLA.
Columbia
Savannah River
Savannah
Port Royal
Beaufort
Charleston
Georgetown
Wilmington
Darien
Brunswick
St. Mary's
Fernandina
Combahee R.
Edisto R.
Ogeechee R.
Altamaha R.
Satilla R.
St. Mary's R.
Santee R.
Santee Canal
Cooper R.
Wando R.
Black R.
Great Pedee R.
L. Pedee R.
Waccamaw R.
Cape Fear R.
South R.
N. Cape Fear R.
ATLANTIC OCEAN
Map of
THE RICE DISTRICT
ALONG THE
ATLANTIC COAST.
Scale of Miles.

visited was probably three-fourths of a mile long and the water extended, when the reservoir was full, a distance of 15 miles from the dam, covering an area of about 20 square miles. Water is taken from the reservoir through a trunk and carried by a system of canals to the different fields. A canal built along one side of the plantation carries away any surplus and gives passage to flood waters. This canal delivers the surplus water into the river somewhere below the plantation. Connecting this canal with the reservoir is a wasteway, by means of which the depth of water in the reservoir is regulated. The wasteway is provided with slash boards and is of such dimensions as to permit the passage of the entire volume of the stream.

LANDS SUITABLE FOR RICE GROWING.

In selecting land for this cereal, the first choice is along some river or stream where the water rises or falls with the tide and yet is not brackish; where the land is low enough to be well flooded at high tide, and at the same time high enough to be well drained at low tide. Those lands permit of the best irrigation that are about 12 inches below high tide and 3 feet above low tide. On such fields water can be raised sufficiently high on all the grain, and the drainage given by 3 feet is rapid and effective. Tidal deltas are largely given over to rice culture. In such localities land is selected far enough from the sea to get fresh water. Suitable lands, however, are found in many places where we do not find these conditions, none of which can be regarded as absolutely essential. We have good rice lands that do not border on and are not near streams affected by tide. We have rice land above high tide, and rice land below low tide, and rice land so close to the ocean that the water of bordering streams is as brackish as the brine from the sea. A rice-producing soil, if above high tide or so near the ocean that the water from a bordering stream can not be used, may be irrigated by water from wells, reservoirs, or inland lakes; if below tide, it may be drained by pumps.

While low-level areas easily irrigated and drained constitute the principal part of the acreage used for rice culture, there are fertile uplands—lands that can not be irrigated in any way—that produce some varieties of rice. On such lands, however, the yield is small and the quality often inferior. Experiments have shown that there are large areas in the United States where upland rice can be grown with a profit. On the highlands of Georgia and the Carolinas marshes are found that are easily irrigated and drained. The fact that in such places the water supply is uncertain and the temperature variable is an objection to these lands.

SOILS ADAPTED TO RICE.

Medium loams underlaid by a stiff subsoil are well suited for growing this cereal. The substratum facilitates drainage, and makes the land firm enough to allow the use of harvesting machinery. Among these are the lands formed by decomposition of vegetation and deposits from the fresh waters carried in the small streams from the interior which are distributed over the lands at high tide, and also the lands reclaimed from marshes or swamps. Only such marshes as can be drained and irrigated from reservoirs, or by water pumped from fresh water streams, can be utilized. Lands that are much elevated above the tide water are usually too poor for the profitable cultivation of rice. Soils containing a large percentage of gravel or sand are not suitable for this industry, from the fact that they dry out too readily and will not hold sufficient moisture. A sandy soil, however, is somtimes found with a subsoil stiff enough to prevent the land from becoming too dry. On such lands one or two medium crops can be raised, seldom more.

VARIETIES OF RICE.

Rice is a plant belonging to the family of grasses. There are many varieties, differing in character, yield, quality and in length of time required for maturing. The varieties differ in shape, size, and color of grain, in the proportion of food contained, and in flavor.

In the Atlantic Coast States there are two principal varieties, the "gold seed" and the white rice. The "gold seed" derives its name from the yellowish color the husk takes on when ripe. This variety is extensively grown in the lowlands of North and South Carolina, and is famous for its yield and quality. The white rice takes its name from the whitish color of its husk and is valued for its early maturity. In the late plantings, which are in June, this variety is usually sown.

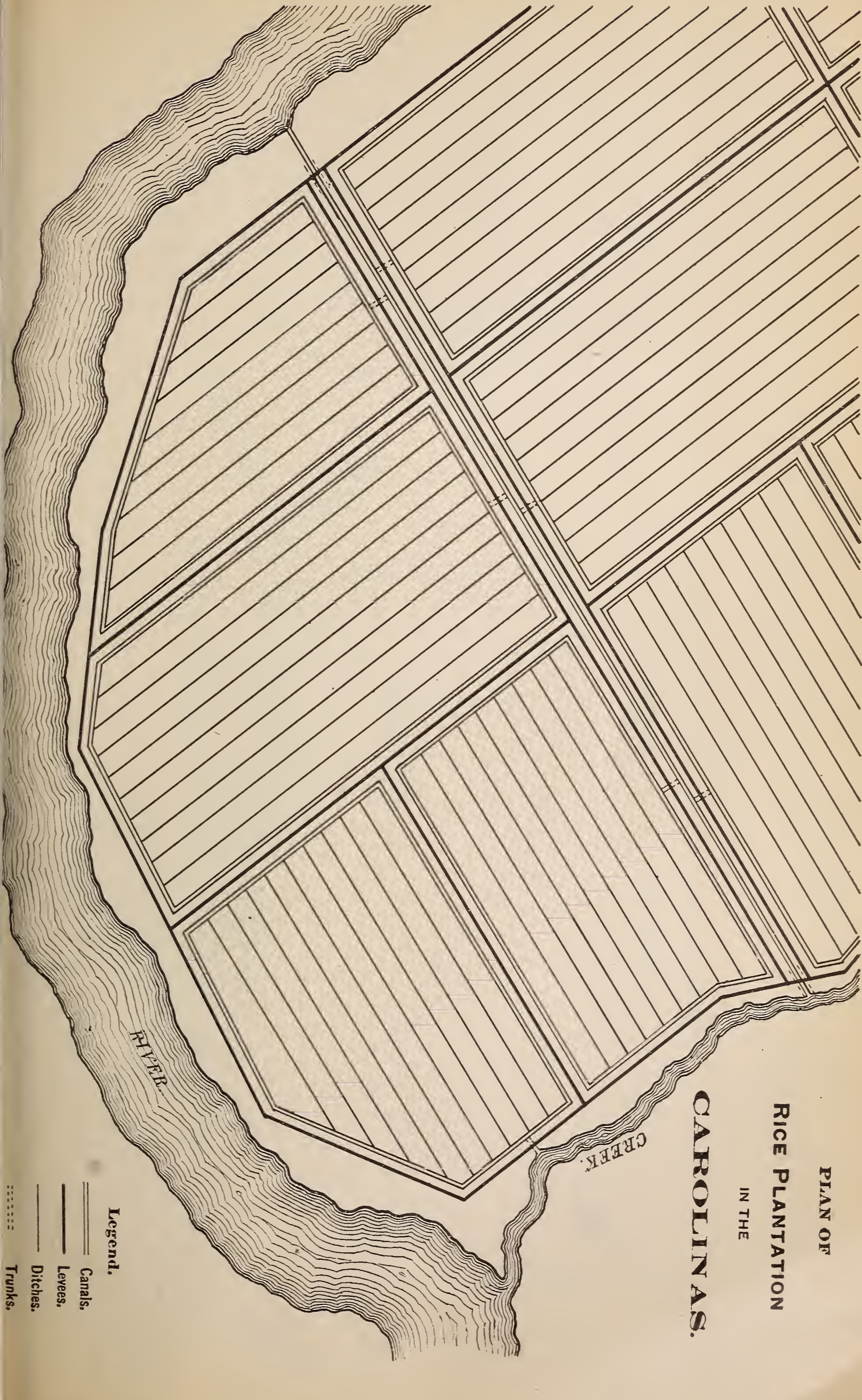
Of late years an effort has been made to introduce Japan rice called "Kiushu." This variety is noted for its short thick kernels and thin hull. It takes on but little polish, and the percentage of bran is, therefore, small.

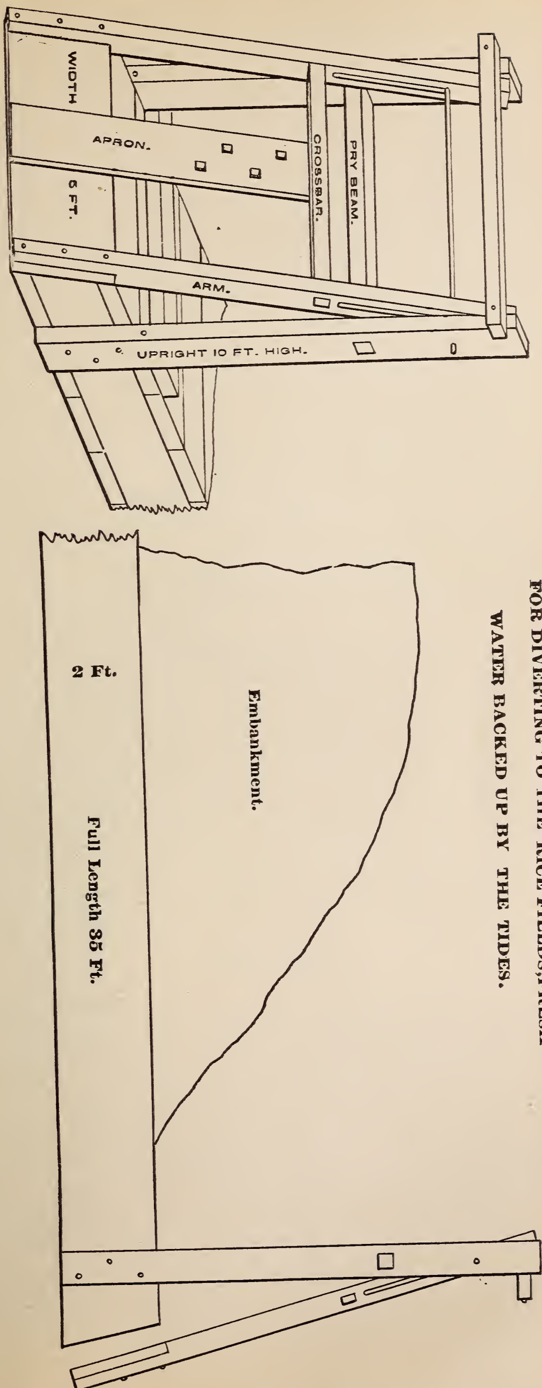
CULTURE.

The methods of irrigation are various, and often crude; in fact, the system of the colonial planter is still in use in many places. A common practice is described below.

PREPARING LAND FOR IRRIGATION.

Suitable land being selected, a bank about 6 feet high, 35 feet wide at the bottom and 12 feet wide on top is thrown up along the river. A main canal is then built, which reaches from the river through the plantation. On each side of this main canal and running parallel with it, banks are thrown up, which join the bank along the river and fol-


PLAN OF
RICE PLANTATION
IN THE
CAROLINAS.
RIVER.
CREEK.
Legend.
Canals.
Levees.
Ditches.
Trunks.



TRUNK

FOR DIVERTING TO THE RICE FIELDS, FRESH WATER BACKED UP BY THE TIDES.

low the main canal throughout its entire length. Along these banks are fields or squares formed by check banks some of which run at right angles, some parallel, to the main canal. Within each of these squares and about 20 feet from its bank is a marginal canal, or face ditch (Pl. XXI). Within this occurs the last and final division of the rice field. These divisions, called beds, are strips of land about 50 feet wide, and of various lengths,—formed by parallel ditches extending from the marginal canal on one side of the field to the marginal canal on the opposite side. Face ditches usually measure about 3 feet in width and 3 or 4 feet in depth. The canals are smaller than formerly. Some of the old canals, however, measuring 6 feet deep and 40 feet wide, are still extant.

The state of the land, the kind of soil and the nature of the subsoil determine the size of the field, which varies from 5 to 35 acres. Fields are laid off in such a way as to be well flooded and effectively drained. If the slope is considerable, the field is small. If the slope is gentle, the field is large. Effective drainage, however, is not the only consideration in laying off the rice field. The land must be so graded that the water will stand at about equal depths in all places. Canals and ditches must be so constructed that each division may be independently flooded or drained.

The surface, to be properly irrigated, should have a uniform grade. An uneven surface requires more labor, produces smaller crops, and in the end damages the soil itself. Too much water in some places, and too little in others, soon show injurious effects on the soil. On such fields the crop does not ripen uniformly; the field shows alternate patches of yellow and green, and the grain when harvested is found very inferior in quality. The planter, whose crop is uniform in quality, knows the value of applying water evenly over the entire surface. The rice lands of the Gulf and Atlantic States have a very gentle slope and do not, as a rule, require much grading.

THE TRUNK.

The marginal canal receives water from the main canal by means of a trunk. In earlier times connections were usually made by headgates, a few of which still remain. At present most connections are made by means of trunks. The trunk is a kind of box, put through the levee to allow water to flow to and from the fields. (Pl. XXII.) Trunks vary in size, the amount of water to be passed determining the dimensions. A trunk 2 by 6 feet will pass sufficient water for 10 acres of land. The material used in making this box is heavy lumber of about 4 inches in thickness. Each end is provided with a "gate." This is simply a board or plank of such a size as to close the end of the trunk. The gate acts as a valve, and is arranged with uprights and cross-arms in such a way that it can be lifted up with a lever.

To flood the field the operator pries against the cross-arm attached to the gate on the exterior end of the trunk—on the end lying in the river. The gate is lifted up; the water rushes in from the river and pushes the interior gate open and passes from the trunk into the canals and ditches and floods the fields.

The water is let off at low tide when the water within the fields is higher than the water in the river. With a lever, the operator pries against the cross-arm attached to the gate on the interior end of the trunk—on the end lying in the rice field. The gate is lifted up, the water rushes into the trunk, pushes open the exterior gate and passes into the river. This continues until the field is drained or until the tide commences to rise again, when the exterior gate automatically closes by reason of the pressure from the outside. Thus it may be seen that no water can pass in or out of the field by accident, while the trunk is in working order. The tide may begin to recede while the planter is in the act of flooding, but the water on the field will not flow out, for the interior gate, acting as a valve, closes by reason of the pressure from the inside. On the other hand, the tide may begin to rise while the planter is in the act of draining. In which instance, however, the water will not enter the field, for the rising tide at once closes the exterior gate.

DRAINAGE.

Drainage is very essential to rice culture. Planting, cultivating, and harvesting all depend, to a considerable extent, on drainage. On grounds insufficiently drained planting is never well done, for the ground can not be put in condition. Cultivation is greatly impeded. Men can not go on the fields to work, the ground can not be stirred, and weeds and noxious grasses flourish.

Before the crop can be harvested, it is necessary that the field be drained. When the land is wet and soggy the harvester works at a great disadvantage; the fields are dug up by the laborers; the surface becomes soggy, clammy, and sour. On account of the insufficient drainage the grain is often taken from the fields to some high place where it is stacked and cured.

It has been suggested that draintile could be used to advantage and profit in these fields. Draintile would, no doubt, be a great improvement to the lands were it not for the sediment carried by the water during the freshet seasons. This soon collects in the tiles and fills them.

When water is taken from lakes or reservoirs where the water is clear tile drainage appears quite practicable. By means of it cross ditches could be done away with and the crude methods of harvesting now employed be succeeded by the use of the most improved machinery.

PLOWING.

In the Carolinas and Georgia the lands, as a rule, are prepared for planting in December and January. The ground is plowed 3 or 4 inches deep, run over with a disk harrow, and then a roller, breaking up the clods and making the surface level and compact. In different sections the time for plowing varies and the methods differ. In some instances, the soil is so stiff that it is necessary to flood the fields before they can be plowed.

Rice is a shallow feeder. Some planters are, therefore, of the opinion that deep plowing is unnecessary. It might appear, however, since rice is a shallow feeder, that deep plowing would give new land each year for the plant. In upland culture the ground is prepared as it is for corn, and in North Carolina the crop is raised much in the same way.

FERTILIZERS.

On lands that are flooded by rivers that carry a rich sediment, sufficient nutritive material may be deposited to insure its continued fertility. On lands not so favorably situated the soil becomes greatly impoverished if some fertilizer is not used. Many different kinds of fertilizers are in use in the rice belt. Among these we note cotton-seed meal, blood and bone, kainit, and tankage. The last named is a special mixture for these lands. Most fertilizers contain a large percentage of potash and are spread with very satisfactory results.

In North Carolina where the upland rice is grown fertilizers are little used. But when they are used, the product is heavier and the yield per acre greater. On one plantation in this State where acid phosphate was experimented with the yield was 12 bushels more to the acre and weighed 4 pounds more to the bushel. The amount spread per acre was 300 pounds. As a rule, the application of fertilizers has been followed with gains in the crop sufficient to make it a paying investment.

PLANTING.

Great care is used in selecting seed that it be free from volunteer rice, weed seed, and the seed of injurious grasses; that the kernels be hard and flinty; that they be solid and of uniform size. Uniform kernels are valued because they permit of a higher polish than do kernels that vary.

The seed is sown in March and April. A later crop is sometimes sown in June. For this the white seed is used on account of early maturity. The time of sowing, also, differs in different sections and is affected by weather conditions and the movements of the bobolink (ricebird). Sowing is usually done as soon as possible after the ground is put in condition.

Rice is generally planted with a drill in rows 14 inches apart and covered by means of a harrow. In some fields trenches about 2 inches deep and 14 inches apart are made with trenching hoes and the seed dropped in and covered. Sometimes, in order to save time and labor, the trench is left open, the seed having been clayed in order to prevent it from floating when the field is flooded. This is the open-trench method, and for it the seed is always clayed. Claying consists in stirring the seed in clayed water until a coat of clay covers each grain.

In the North Carolina uplands the common corn drill is used in planting. Planting with a drill insures equal distribution, one of the essentials for the greatest productivity of a given piece of land. The amount sown per acre varies. The average, however, is estimated at 3 bushels.

In some localities birds steal the grain while it is being sown. To prevent this, the seed is sometimes tarred; i. e., given a coat of tar. This method, though a protection, is not an absolute one, as birds have been killed whose craws were filled with the black grains, and whose flesh itself tasted of the tar.

FLOODING.

One of the most important features in the culture of this cereal is flooding. Many planters flood the field immediately after the seed is sown, planting and watering on the same day. This water, called the "sprout flow," protects the grain from the birds and causes germination. The sprout flow is left on the field till the seed sprouts. In early planting this requires from six to eight days. Rice planted in June sprouts in twenty-four hours. When the sprout flow is taken off, the field remains without water until the plants come up and the rows across the field can be plainly seen, when the water is again turned on. This is called the "stretch flow" and remains on the field till the plants are stretched to 5½ or 6 inches. This requires from two to six days, the time depending very largely on weather conditions. The stretch flow serves the double purpose of rendering nourishment available to the rice plant, and impeding and destroying the growth of weeds and injurious grasses.

When the plants have grown sufficiently high under the stretch flow the water is gradually lowered to an average depth of 4 inches, where it remains from thirteen to thirty days, according to the strength of the soil, the condition of the plants, and the temperature. The stretch flow is taken off and followed by the "dry growth," which lasts from forty to forty-five days. During this period the crop is cultivated with horse and hand hoes. All weeds, grasses, and volunteer rice are uprooted and the ground thoroughly stirred. It is during the "dry growth" that conditions are most favorable for grubs, and an intermediate flow is sometimes necessary to protect the crop from these worms.

When the plant begins to joint the "harvest flow" is turned on. First the water is raised till it covers all the high places in the fields, and is held so for three, four, or five days, after which it is lowered to where the stretch flow was. In a few days the water is again raised till it almost touches the rice heads, where it remains till the grain is ripe. The harvest flow extends over sixty-five days, and in order that the water may not become stagnant, it is shifted every ten days. When the grain is ripe the heads bend low. The field is then drained for harvest.

QUANTITY OF WATER REQUIRED.

How much water is required to raise a rice crop in this section is a question very difficult if not impossible to answer. Some fields very naturally require more than others, and by careless irrigation a volume of water many times in excess of that actually needed may be used. The amount of water used, however, is of very little importance, as the supply is almost unlimited, and as to questions of water rights, there are none. The only important question appertaining to water in this section is the method of using it.

CULTIVATION.

During the rice-growing season harmful weeds and grasses grow on the banks and in the fields and ditches. These weeds and grasses must be cut down and their growth prevented. Hand weeding is very effective, and the consequent loosening of the soil is very favorable to the growth of the crop.

In cultivating this cereal the horse hoe, a kind of plow, and the common hand hoe are used. Under the best cultivation the field is horse-hoed once and hand-hoed twice. Where the drainage is poor the horse hoe is not taken on the field and all cultivation is done by hand.

The needs of this plant require that the ground be thoroughly stirred. This places food within reach of the plant and prevents a rapid drying of the soil. Rice can not here be grown successfully without cultivation. The application of water can not take the place of hoeing. On irrigated land the top surface, often flooded, becomes a paste. This when dried beneath a scorching sun becomes hard and baked and forms a crust that arrests the growth of the plant.

HARVESTING.

In these States harvesting machinery is not used. All the rice is cut with the hand hook or sickle. The beds, in order to permit of complete drainage, are made very narrow and usually small. For this reason the harvester can not be used without great loss, due to the amount of grain broken down and wasted in operating the machine.

Rice is cut when the straw barely begins to color, when the lower part of the head (about one-eighth) is still "in the milk." If cutting

is delayed until the entire head is quite ripe, the quality is inferior and the quantity greatly reduced by the loss incurred by shelling out in handling.

It is cut 10 or 12 inches from the ground, leaving a high stubble, on which the grain is placed to cure. In about twenty-four hours, when the grain is thoroughly dry, it is bound into sheaves, tied with straw, and shocked. The laborer waits in the morning till the dew passes off before making the cock stack. As soon as possible, in order to avoid the danger of storms, the sheaves are taken in carts and wagons to the thrashing mill, one of which is located on each plantation. Some planters have a "stacking yard" (Pl. XXIII) on high grounds safe from floods and storms, where, after the grain is cut, it is carried and stacked.

Harvest work is given in tasks to colored men and women. They cut, tie, and put the sheaves in cock stacks for $2 per acre.

THRASHING.

Thrashing is done on nearly all plantations with a steam thrasher not unlike the machines used in thrashing wheat. The machines are

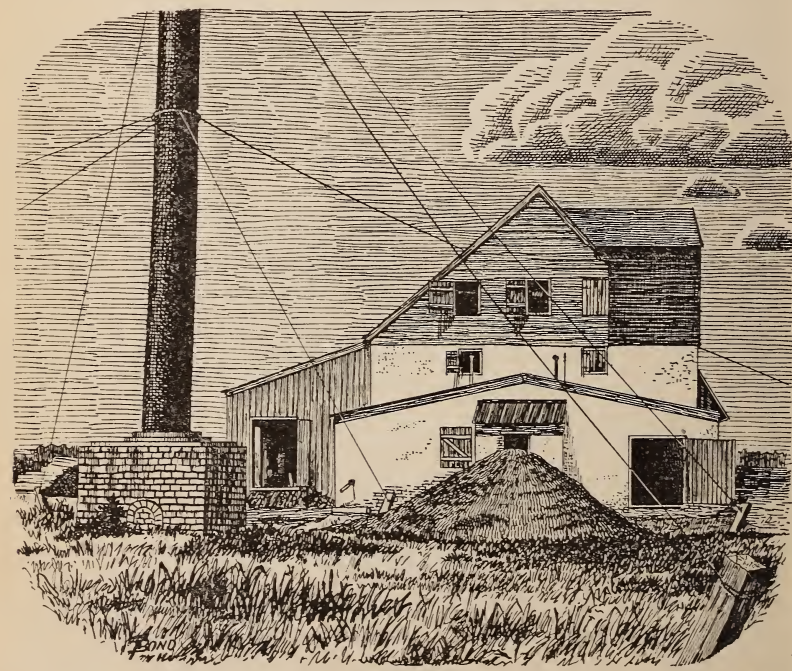
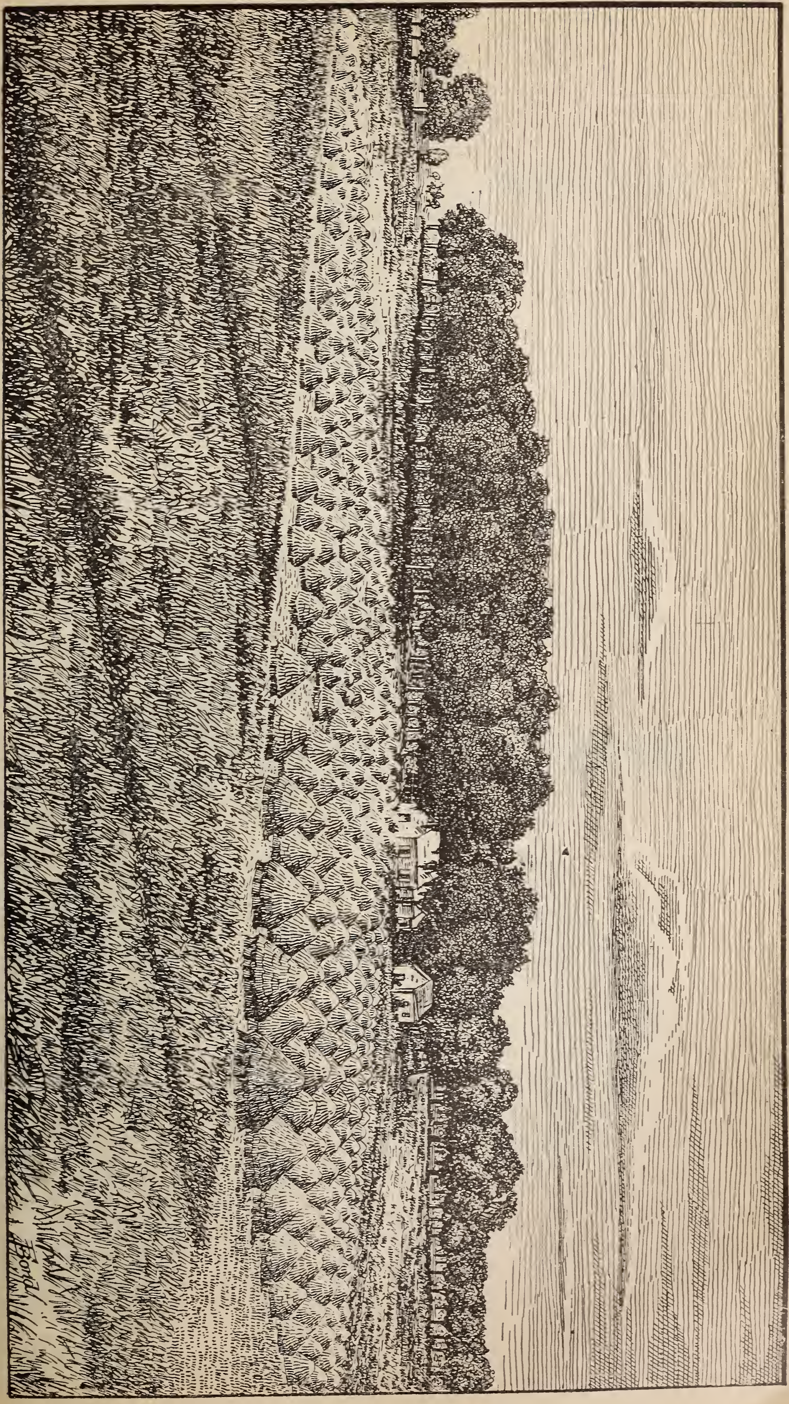
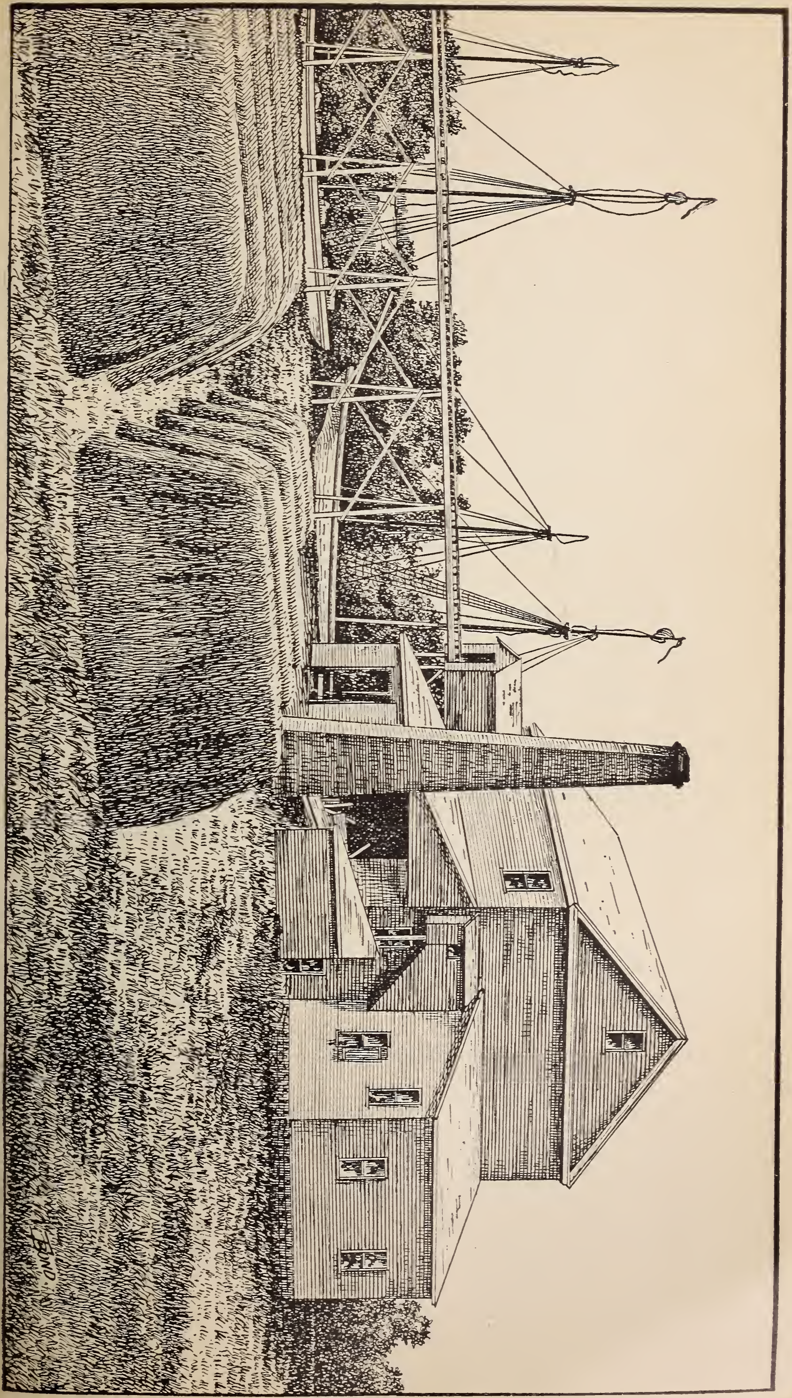


FIG. 10.—Thrashing mill, Oakland plantation.

stationary and very large. Thrashing mills (see Pl. XXIV and fig. 10) are located on tide-water canals or on the banks of streams, in



RICE STACK YARDS.



THRASHING MILL, COMBAHEE RIVER, SOUTH CAROLINA.

order that tugs and "lighters" may come to the mill and carry the produce to market. In the process of thrashing the grain is thoroughly cleaned by fans and screens, which remove all the light and inferior grains, chaff, etc., from the marketable article. This is then carried by elevators into large bins, where it is stored. Great care is taken that the grain be thoroughly dry before thrashing.

MILLING.

Rice, as it is taken to the mill, is called "rough rice" or paddy. It has two coverings—a thin, close cuticle, encased by a coarse, thick, stiff husk. Milling consists in removing these coverings. In the process 20 pounds of husks are taken from 100 pounds of paddy.

The grain is usually brought to mill in boats and taken from the boats by elevators. The first operation the paddy undergoes in the mill consists in recleaning, after which it passes between milling stones distant from one another by about two-thirds of the length of the grain. These tear off the husks, and, as the product passes over screens and bellows, the chaff and grain are separated. The grain is now placed in mortars, wherein the cuticle is removed by pounding with pestles. When the cuticle is removed, the contents of the mortar is an oily mixture of rice flour and chaff. This now passes over "flour screens," by means of which all flour is removed. The "chaff fan" is then used, and the rice delivered as clean grain is run into cooling bins. In the preceding processes so much heat has been generated that cooling is necessary. For about nine hours the grain remains in the cooling bin, after which one more separation takes place. By means of "brush screens" the large rice is separated from the smaller, and the little flour that has not yet been removed is brushed from the grain. The product is now ready for the final process, polishing.

The old method of milling consisted in placing the paddy in a hollow stone or log and pounding it with a pestle until the hulls were removed. The bran and hulls were then fanned from the grain.

POLISHING.

The commercial article is always polished. This consists in giving the grain a glossy appearance and makes much difference in the market value. The process that gives the gloss removes much of the most nutritious parts of the grain, including nearly all of the fats and most of the flavor. The food value of rice flour is many times greater than the food value of the polished product. Polishing is effected by pieces of skins passing over the rice and by giving a thin, fine coat of paraffin. Within a cylinder of wire gauze revolves a cylinder of wood, around which sheepskins are tacked, wool inside. This gives a soft

surface, over which tanned skin worked to a velvet-like softness is fastened. The grain, with a piece of paraffin, is put into the large cylinder. The cylinder revolves, and passing the soft surface over the grain gives the pearly luster.

RICE STRAW.

For a long time rice straw was regarded as waste and burned in the field. Sometimes it was used as fuel at the thrashing mill, as is the custom still with some planters. This straw, however, has a practical food value. It contains proteins, fats, and carbohydrates in such proportions as to be a good forage for stock. For packing purposes there is no better straw, and in recent years it has been baled and placed on the market.

RICE FLOUR.

This is a fine, oily meal taken from the grain in the processes of polishing and pounding. It is rich in fats and is a healthful food for man and beast. The food value of rice flour is much in excess of the food value of the commercial article. Not being so palatable as healthful, however, the flour is used only as a stock food.

COST.

The initial expenses are, of necessity, heavy. The average cost to bank and place trunks and do necessary grading on cleaned ground is about $25 per acre. Timbered land may be cleared for about $75 per acre. The cost, therefore, of converting timbered land into a rice field, with its canals, banks, and ditches, is about $100 per acre. To put the ground in condition, cultivate, harvest, and prepare the grain for market costs the planter from $20 to $25 per acre. For milling and handling by a broker, the expense the planter must meet equals about 20 per cent of the value of the product.

In the rice belt, factors furnish the planters money at 8 per cent, and usually take a lien on the crop, real estate, farming implements, and outfit. The crop is delivered to the factor, who sells it for a commission of 2½ per cent. Planters that are not obliged to borrow money sell through a broker at an expense of 1½ per cent.

LABOR.

Labor is done by colored men and women. The prices paid vary but little, and range from 40 to 50 cents per day. Labor is generally given out in tasks at 40 to 50 cents per task. Some planters contract with the laborers for a year's work. The laborer receives a given tract of land, usually an acre, on which to raise rice for himself and family, a cabin, wood, and all the upland he wants for garden truck.

For this he agrees to work one day of each week for a year, or eight or nine months, and during the remaining time to hire to the planter for a stipulated sum per task.

All fields are laid off in half-acre divisions, called tasks. To hoe one of these divisions, or to plow three of them constitutes a day's work. Harvest work is given out at $2 per task.

The condition of the laborer from an educational standpoint is a matter of vital importance to the future of this and every other industry of this section, but is, at the same time, a question not to be discussed in this bulletin.

VALUE.

Good rice generally brings from 60 cents to $1.15 per bushel. It does not often sell for less than 60 cents and seldom brings more than $1.15. Upland rice is not so valuable as the lowland product, which brings about 20 per cent more. The upland culture in many parts of North Carolina has of late years been almost discontinued on account of the low price offered for the product.

PROFITS.

Before the civil war the planter realized 4 or 5 per cent on his investment in the rice business, valuing his slaves employed at from $500 to $800 per head and reckoning them as part of the investment. The planter now realizes from 6 to 10 per cent on the investment.

LOSSES.

The principal and greatest loss sustained by the planter is due to storms. In 1893 all the fields along the Combahee, Edisto, Savannah, Ashepoo, Cooper, and many other streams were devastated by storms. The waters beat against the banks and levees till they gave way, rushed in, and rolled over the fields, destroying the grain, beating it from the earth, filling up ditches and canals, and making mud heaps of banks and levees.

RED RICE.

In harvesting more or less seed falls to the ground, especially at places where sheaves have been stacked and along the driveway from the fields to the barnyards. The seed that is not destroyed by sprouting and burning remains in the ground and grows up with the following season's planting. This volunteer plant produces red rice, so called because of the pink cuticle next to the kernel. The great objection to red rice is that it is soft, so soft that it can not be milled, and is, therefore, unmerchantable. The grain scatters out readily, and, reseeding the field, produces more and more of its kind. In some instances it has increased so rapidly and taken so firm a hold on the

ground that it has been necessary to leave whole fields idle for a year or more in order to free the ground from this noxious plant.

To eradicate red rice the field is flooded immediately after harvest. This sprouts the scattered grain. Late in the fall, when it has grown up, the field is drained as dry as possible and then burned.

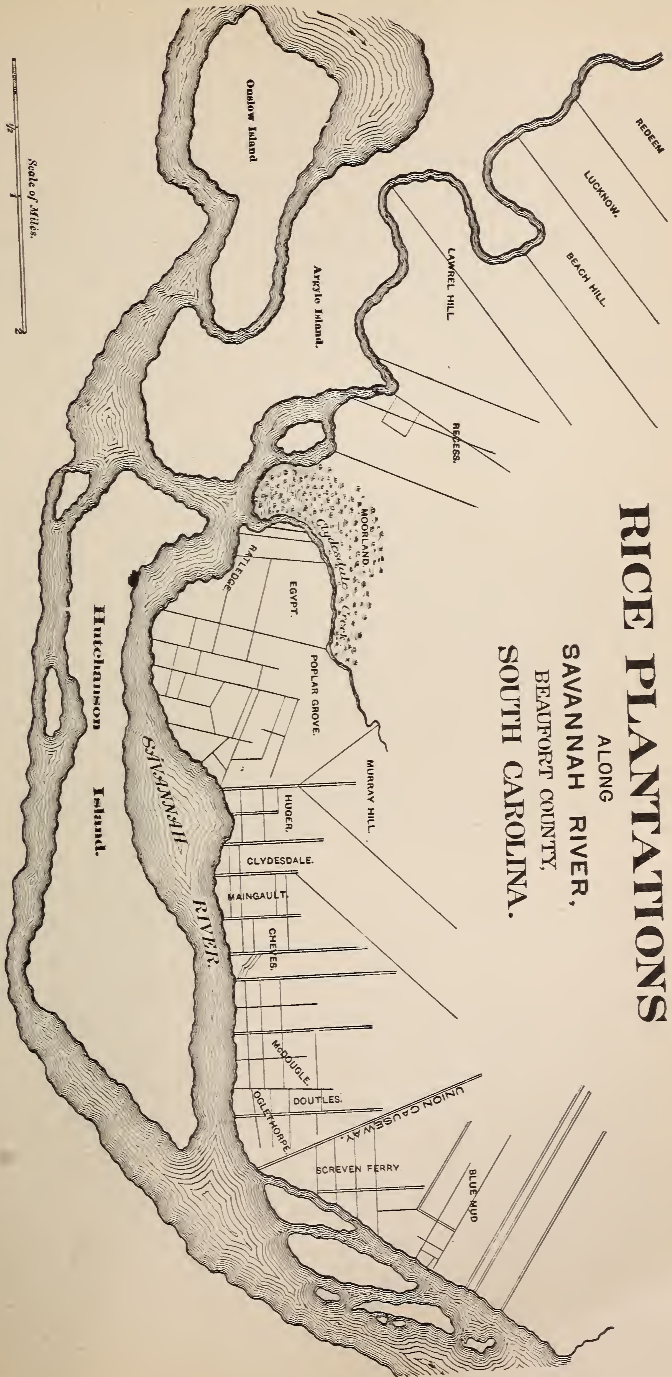
BIRDS.

Ricebirds, blackbirds, grubs, maggots, and worms are the principal pests of the rice fields. Of these, the most troublesome is the ricebird, commonly known in the North as the bobolink. Early in the spring the bird begins to migrate from the extreme South and, arriving in the rice belt about planting time, preys on the seed that has been scattered. Or, arriving a little late, when, perhaps, the crop has sprouted and shoots have been formed, the bird pulls up the plant, roots and all, and feeds on the sprouted kernels. Its stay in the field this time, however, is short, as it moves on northward to nest.

When nesting is over and the young have become sufficiently strong, the flocks unite and begin their return to the South. They arrive in the rice belt about the middle of August. Thereafter, until their departure, there is trouble for the planter. The birds swarm on the fields in countless numbers and are driven from one place only to settle down on another. If the grains have hardened before their arrival but little damage is done, but when the grain is "in the milk" great quantities are devoured, and the loss at times has been so great, in places, that it was found unprofitable to cut the grain. When the grain is palatable the invasion of these birds is most ruinous.

The preventives employed against these birds are only palliative, and the expense incurred is considerable. Men and boys armed with muskets and shotguns discharge blank cartridges to scare the birds away. Shot is seldom used as it damages the crop. One man imperfectly protects four or five acres, and shoots about one quart of powder per day. Firing commences at daybreak and continues until night. These men and boys are called "bird minders." Small flags and kites, some with suspended looking-glasses, are flown over the fields. Another method consists in placing a piece of stale meat on a pole in the rice field. This attracts buzzards. The ricebird, for a while, takes the buzzards for hawks and stays at a distance. Soon, however, the bird becomes accustomed to the buzzards and pays no attention whatever to them.

When the seed is sown to "meet the bird," i. e., to be in the milk when the bobolink arrives, the entire crop will be destroyed, if extraordinary care is not exercised on the part of the bird-minder. The average loss due to this bird is estimated in many places at 4 to 4½ bushels per acre. The blackbird is always about and ready to forage. The damage done, however, is but little.


RICE PLANTATIONS
ALONG
SAVANNAH RIVER,
BEAUFORT COUNTY,
SOUTH CAROLINA.
Scale of Miles.
1/2
1
2
Onslow Island
Argyle Island
Hutchinson Island.
SAVANNAH
RIVER.
REDEEM
LUCKNOW.
BEACH HILL.
LAWREL HILL
RECESS.
MOORLAND.
Clydesdale Creek
RATLEDGE.
EGYPT.
POPLAR GROVE.
MURRAY HILL.
HUGER.
CLYDESDALE.
MAINGAULT.
CHEVES.
McDOUGLE.
DOUTLES.
OGLETHORPE.
UNION CAUSEWAY.
SCREVEN FERRY.
BLUE MUD

ABANDONED LANDS.

Much abandoned land lies along the Southern rivers, where there is tide water. These lands are covered with a dense growth of marsh weeds. Many of these now abandoned lands were once fields of industry and productivity. The soil is rich, and with proper irrigation and drainage would make good rice fields. Much of these tide-water lands can be so reclaimed, and some of them are. Those that sold for $120 and $200 per acre before the war can now be purchased for $0.50 to $1.50 per acre, so that if rice-growing continues to be a success there is a good opportunity here for investments. Some of the land under old reservoirs appeared, however, to have been worn out and abandoned before the war. These lands are covered with scrubby oaks, other native timber, and underbrush.

PROSPECTS FOR THE FUTURE.

What actually is the prospect for this industry east of the Mississippi River is a question concerning which men who have studied the problems may differ. The civil war caused many plantations to be suddenly abandoned. Since then the industry has appeared broken and unable to regain its former footing. The grain, to be sure, is raised with profit along many Southern rivers. The area devoted to this industry along this coast we have reason to believe will be increased, but in no extended way without assistance from the Government in the construction of banks along tide-water streams.

RICE PLANTATIONS ON THE RIVERS OF NORTH CAROLINA, SOUTH CAROLINA, AND GEORGIA.

The pages which follow give the area of the rice plantations along the rivers of North Carolina, South Carolina, and Georgia, and the area cultivated during the season of 1901 with the yields and prices of the product.

On the Savannah River there are 23 rice plantations containing an aggregate area of 10,635 acres, of which 4,385 acres were cultivated in 1901. (Pl. XXV.) At one time, before the war, there were 18,000 acres of rice cultivated along this river. On the Georgia side alone there were 5,000 acres, whereas at present there are only 1,200. The average yield on this stream is about 33 bushels per acre. The cost of production varies from $18 to $20 per acre. The Savannah River carries a sediment that greatly enriches the soil. The average deposit for each year is about one-half inch. For the past eighteen years there has been an average loss of about one crop in three. This has been due chiefly to storms, which flood the fields often after harvesting has begun. Prior to the civil war, the average loss by overflow was one

crop out of twenty, and the story is often told of the sire who, in transferring the plantation to his sons, cautioned them against this loss, urging them to so care for the lands and manage their affairs that once in every twenty years they would be able to sustain the loss of an entire crop. One explanation of the more frequent losses is that it is caused by the Government improvements at the mouth of the river. These are planned to confine the stream at the mouth of the river in order to create a deep, narrow channel by driving piles along the river. It is insisted by some that these improvements retard the natural flow of the water by acting as a dam and causing the water to back up the river and overflow the adjacent lands. Suits have been brought against the Government for alleged damages caused by these improvements. Opposed to this is the opinion of well informed men in the district that storms at sea are more frequent and violent now than formerly, and much speculation is indulged in as to the cause of this. The more frequent occurrence of freshets may be accounted for by the fact that the mountains of the interior, where the streams rise, have been denuded of their timber. The water from rains runs off much more quickly from the cleared land than it formerly did from the forests.

Thirty-four plantations are located on Combahee River, having an aggregate area of 12,591 acres, of which 10,166 acres were cultivated in 1901. (Pl. XXVI.) Thirty-five bushels per acre is the average yield on these plantations. The cost per acre for planting, cultivating, harvesting, thrashing, and plantation repairs is about $25. The average yield on the inland plantations, near this river, is about 25 bushels per acre. The cost per acre of such culture is about $18. These estimates of cost are the result of careful inquiry among leading planters. The loss of crops from storms averages one in ten. The storms of 1893 swept over this section and wholly destroyed the year's product. Fertilizers are not generally used on these plantations. When used, however, the condition of the land determines the time when the fertilizer should be spread. If the soil be very poor, it is spread before planting, otherwise during the dry growth and hoed into the ground during cultivation. Tide irrigation on this river extends about 40 miles from its mouth. Labor, which is done by colored men and women, commands a somewhat higher price on the Combahee than on other rivers by reason of a greater demand for labor in the near-by cotton fields. The planter usually contracts to furnish the laborer a cabin, one acre for rice, and all the upland he wants for garden, for which the laborer agrees to work for the planter one day of each week for a period of eight months, and during the remaining time hires to the planter for a stipulated sum per task.

The aggregate area of the 14 rice plantations along Ashepoo River is 3,295 acres, of which, 1,840 acres were cultivated in 1901. The

VIEWS ON COMBAHEE RIVER, SOUTH CAROLINA.

average yield per acre on these plantations is about 35 bushels. The land is not so well adapted to rice growing as the land along the Edisto River. The drainage is bad, and the supply of fresh water limited; yet some of the very best plantations of the rice belt—plantations most modern in improvements and under the highest state of cultivation—are found along this river.

On the Edisto River there are 9 rice plantations, having an aggregate area of 4,970 acres, but 3,410 acres of which were cultivated in 1901. The average yield on this river for the year 1900 was 46 bushels per acre. Some fields have produced as much as 80 bushels per acre. The cost of production ranges from $20 to $25 per acre. Fertilizers are extensively used on these lands. Cotton-seed meal, blood and bone, and kainit are spread. The latter is largely used on the upper plantations. Labor is done by colored men and women, who receive 40 to 50 cents per day. In harvest time $2 per acre is paid for cutting, binding, and stacking the grain in cock stacks. Written contracts are usually drawn up whereby the laborer agrees to work one day in each week for one year, for which he receives 40 bushels of rice and a cabin to live in. During the balance of the time he works for the planter at a stipulated sum per task. The improved lands of the Edisto River are valued at from $25 to $75 per acre. (Pl. XXVII.)

Cooper River has 41 rice plantations, with an aggregate area of 6,050 acres, of which 4,530 acres were cultivated in 1901. The average yield on this river now is about 30 bushels per acre. Formerly the yield was much greater, having averaged at one time 50 bushels. Fertilizers containing a large percentage of potash are used on these plantations. Kainit is not used, as the lands carry a considerable amount of salt. The lands are low, giving an average drainage of 1 foot. This not being sufficient, some planters have large pumps with which to remove the water. The Cooper River flows through a rich rice section. The land is exceedingly fertile, and with proper drainage valuable crops are produced.

Thirty-nine plantations are located along the Santee River, containing an aggregate area of 16,760 acres, of which 3,950 acres were cultivated in 1901. The average yield on this river is 30 bushels per acre. The average tide is 4 feet. The drainage is good. The Santee River has higher tides than the Edisto or the Combahee. Much of the land along it is above high tide and not suitable for rice, the soil being too light. Land under the tide requires heavier banks to withstand the greater tide, and it does not appear so fertile as that along the Edisto or Combahee. The expense of keeping the banks in repair along this river is also much greater. The rice raised along this river, however, is of good quality and the planter reaps a reasonable profit.

Along the Sampit River there are 7 rice plantations, with an aggregate area of 1,725 acres, of which 970 acres were cultivated in 1901.

On the Black River are 16 rice plantations, having an aggregate area of 4,335 acres, 3,060 acres of which were cultivated in 1901. The average yield on this river is about 30 bushels per acre. The average tide is 4 feet; average drainage 2 feet.

The aggregate area of the 22 rice plantations on the Peedee River is 5,310 acres, of which 2,240 acres were cultivated in 1901. The average yield on the Peedee River is about 30 bushels per acre.

On nearly all these plantations we find the following labor scale:

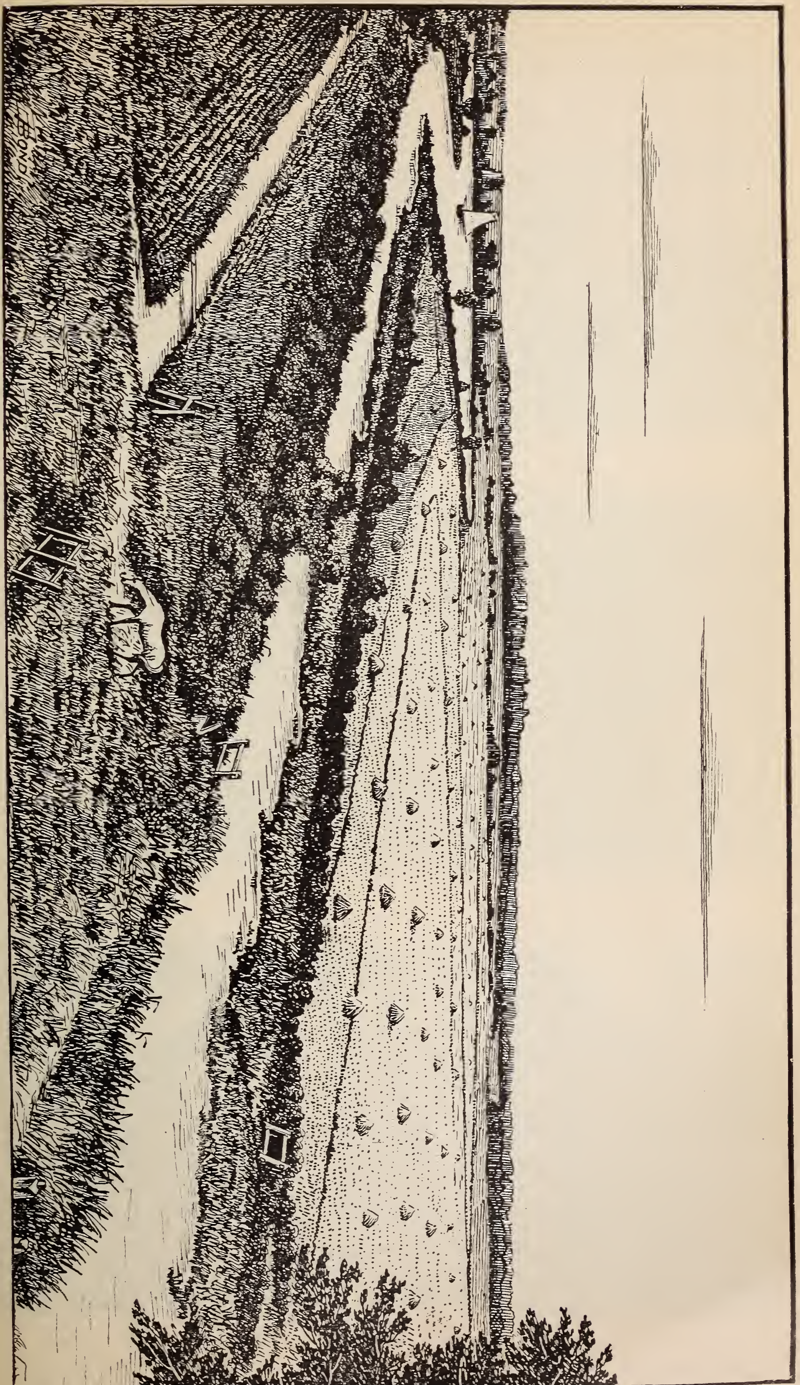
	Cents.
For hoeing one-half acre by hand	20
For hoeing one-half acre by horse hoe	20
For cutting one-half acre	40–50
For binding one-half acre	20–30
Miscellaneous jobs, per task	40

Some of these plantations have a tide of 4 feet. The drainage near the mouth of the river is about 2 feet.

On the Waccamaw River there are located 27 rice plantations, with an aggregate area of 7,425 acres, of which 3,675 acres were cultivated in 1901.

On the Cape Fear River there are 9 plantations, containing an aggregate area of 1,975 acres, all of which are cultivated. The average yield per acre on this stream is about 40 bushels. The total yield for 1900, however, was but 50,000 bushels. This diminution was due to freshets in the harvest season. The cost of production ranges from 40 to 75 cents per bushel. The acreage is much reduced from what it was formerly. The drill and harrow are not used on these plantations. The ground is plowed about 2 inches deep and laid off in rows 15 inches apart. The seed is clayed and planted in open ditches. Drainage is poor, so poor, in fact, that the plow is not used in cultivating the crop. To bring mules onto the ground to move the grain it is necessary to fasten clogs to the animal's feet. Some of the plantations are so near the sea that water from the Cape Fear River can not be used on account of the salt contained in it. Such plantations obtain their water supply from lakes or reservoirs. They are drained principally, some wholly, into the river as it recedes with the ebbing tide, but when drainage is insufficient, pumps are used to remove the water left on the field. The lift from the bottom of the drainage ditches over the banks is about 8 feet. On one of the plantations visited two pumps were in operation, the capacity of the larger being 2,000 gallons per minute, and of the other about one-half of this. The pumps were set on piling foundations. An effort was made to ascertain the cost of operating these pumps, and also their value as measured in the crops they had saved, but without success, as no records had been kept by the superintendent of the plantation.

Along the Satilla River there are 18 rice plantations, with an aggregate area of 4,655 acres, of which 3,025 acres were cultivated in 1901.



RICE PLANTATION ALONG EDISTO RIVER, SOUTH CAROLINA.

VIEWS ON HALLS ISLAND, SOUTH CAROLINA.

The average yield per acre on this river is about 40 bushels. The cost of production on these plantations is about $20 per acre. The mean tide is 7 feet Occasionally, when this stream is low, the salt water ascends the river for some distance and renders it unfit for irrigation.

TRUCK FARMING BY IRRIGATION.

Recent development of truck farming along the Atlantic coast has prompted Donner Brothers, proprietors of Halls Island Farm (Pl. XXVIII), to utilize artesian wells for irrigation. This island is in Beaufort County, S. C., and contains an area of about 1,000 acres. The surface is even and from 2 to 20 feet above high tide. One hundred and sixty acres are irrigated from two wells, one of which is 6 inches in diameter, the other 10 inches. Each is about 140 feet deep. The larger well discharges about 500 gallons per minute and is provided with an 80-horsepower steam pump. The smaller well has a 12-horsepower engine.

From the pumps water is forced through 5-inch mains and diverted to the various fields through 3-inch pipes. The pipes, all of which are buried in trenches, in order that they may not interfere with cultivation, are provided with connections for hose, by means of which water is evenly distributed over the surface. The total length of pipe used is about 2½ miles. The ground, underlaid with 2½-inch drain tile, is thoroughly drained.

Asparagus, peas, potatoes, lettuce, beans, and other vegetables are raised in large quantities and shipped in car lots to Eastern markets. All of these products are of a good quality and find a ready sale.

The expense of this industry is considerable, and the management of each feature is thoroughly scientific.

Some time will be required to determine whether or not this method of farming is profitable, and upon the results depends the further extension of the industry in this locality.

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